U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF SOILS
IN COOPERATION WITH THE UNIVERSITY OF CALIFORNIA AGRICULTURAL EXPERIMENT STATION

SOIL SURVEY OF THE PALO VERDE AREA CALIFORNIA

BY

A. E. KOCHER, IN CHARGE, AND F. O. YOUNGS

[Advance Sheets—Field Operations of the Bureau of Soils, 1922]

WASHINGTON
GOVERNMENT PRINTING OFFICE
1926

[PUBLIC RESOLUTION—No. 9]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided,* That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

CONTENTS

ILLUSTRATIONS

PLATES

FIGURE

MAPS

SOIL SURVEY OF THE PALO VERDE AREA CALIFORNIA

By A. E. KOCHER, in Charge, and F. O. YOUNGS

DESCRIPTION OF THE AREA

The Palo Verde area is situated about 40 miles northeast of the Imperial Valley, near the extreme southeastern part of California. Blythe, the principal town, is about 200 miles east of Los Angeles. The area comprises the Palo Verde Valley lying along the Colorado River, the Palo Verde Mesa with a number of detached desert mountains, and a narrow strip along the east side of the Colorado Desert comprising a part of the Chuckawalla Valley. The greater part of the survey lies in the southeastern corner of Riverside County; a strip about 3 miles in width extends south into Imperial County. The Colorado River forms the east boundary and separates the area from the State of Arizona. The north boundary is formed principally by the Santa Maria Mountains, the south boundary by an east-and-west line extending through the foothills of the Palo Verde Mountains, and the west boundary is mainly a north-and-south line extending through Ironwood Mountain and thence south across the desert along the west side of the Mule and Palo Verde Mountains. The area is roughly rectangular and comprises 423 square miles, or 270,720 acres. Generally speaking, it consists of two divisions, the low, recent alluvial lands known as the Palo Verde Valley, elevation 240 to 275 feet above sea level, and the higher desert lands bordering the valley on the west. From the agricultural standpoint, the Palo Verde Valley is much the more important. It extends from the Blythe Intake on the north where the Santa Maria Mountains completely shut off the lowlands, southwestwardly a distance of 30 miles, where it is again pinched out by the encroaching foothills of the Palo Verde Mountains. The valley is crescent shaped and reaches a maximum width of about 10 miles between the towns of Blythe and Ripley. Except in a number of places where small areas are dotted with wind-blown mounds, 3 to 20 feet in height, the surface is generally smooth, with a uniform slope from north to south of about 1½ feet to the mile. The highest part of the valley is on the east side along the river, the

FIG. 17.—Sketch map showing location of the Palo Verde area, California

fall from east to west ranging from 1 to 1½ feet to the mile, the river bank at Ehrenberg, on the east side of the river, being 11 feet higher than the foot of the mesa west of Blythe.

The surface drainage of the valley is effected by a number of sloughs or lagoons roughly paralleling the river, and a number of minor drainage ways formed by recurring overflows. Excepting a few of the larger lagoons, which are filled with water, more or less stagnant the year round, none of the drainage ways carry water except after floods or infrequent rains.

Prior to settlement, the valley was rather thickly covered with mesquite (*Prosopis juliflora*), cat's-claw (*Acacia greggii*) and other shrubs, with cottonwood, willow, and arrow weed (*Pluchea sericear*) near the river. Most of the northern part has been cleared and placed under irrigation, but a large proportion of the south half of the valley is still covered with native shrubs and small trees.

Separating the valley from the mesa lands is a steep escarpment 80 to 130 feet in height. (Pl. XV, fig. 1.) Only about 2,300 acres of the mesa, however, is as low as 80 feet above the valley. This area occurs as a comparatively level flat directly west of Blythe. This tract is unbroken by drainage ways, could be easily leveled, and has a deep, sandy soil well suited to irrigation.

The first bench is separated from the main body of the mesa by a short slope about 50 feet in height. Beyond this slope to the west the mesa rises gradually for a distance of 3 to 10 miles, terminating abruptly in the steep, rocky slopes of detached mountain masses. Along the foot of the mountains and extending 1 to 3 miles eastward from their base, the mesa consists of steep alluvial fans containing an excess of gravel and angular rock fragments which, together with the high elevation, completely unfits the land for agricultural use. Beyond this toward the east the slope is fairly uniform and gentle, the surface is but little marked by drainage channels, and the soils are usually free from excess of gravel or other coarser material. It is reported that about 13,000 acres of this could be irrigated by a lift of 130 feet, and that about 4,000 acres additional could be watered by pumping 140 feet above the present supply of water in the valley. There are, however, within this area a number of bodies of old stratified materials which are strongly impregnated with alkali. The largest smooth body on the mesa extends along the McCoy Wash in a northwesterly direction into the northwest corner of the area mapped. Although the surface of this body is favorable for irrigation, the elevation is such that the expense of development and the subsequent cost of operation would probably be prohibitive.

The area mapped includes a part of four separate mountain areas. The Santa Maria Mountains, including about 10 square miles in the northeast corner of the area, is a rugged, stony mass whose eroded slopes are almost barren of normal forms of vegetation. That part included within this survey consists principally of maturely eroded foothill slopes separated from the valley by a sharp escarpment 50 to 100 feet in height and, farther west, merging into the smoother mesa through a series of rounded stony hills. Its southern front has a

northwest-southeast trend below which, on the southwest side, is the narrowing embayment of the mesa plain extending along the McCoy Wash into the northwest corner of the area surveyed. This plain has an average width within the area surveyed of about 10 miles. Although the surface is cut by numerous minor drainage ways, the topography is such that when viewed from a distance it has the appearance of being practically level.

Bordering this valley on the southwest are the steep, barren slopes of Ironwood Mountain. This is an especially stony range projecting into the area from the northwest and terminating in a point on the Mecca-Los Angeles Highway, about 9 miles west of Blythe. Its slopes are not only rugged and barren, but they have contributed large quantities of stony material to adjacent alluvial fans, rendering a strip 2 to 3 miles in width along the base entirely unfit for cultivation.

South of Ironwood Mountain there is a desert pass 4 to 5 miles in width which separates this range from the equally rugged mountain mass locally known as Mule Mountain. The pass has the appearance of being nearly level, but near the west boundary of the area surveyed there is a low divide beyond which to the west the meager drainage is westward into the extensive interior basin known as the Chuckawalla Valley. The pass is occupied by porous, gravelly soils and several square miles of billowy, shifting Dunesand. Its elevation ranges around 200 feet above the floor of the Palo Verde Valley.

Mule Mountain occupies about 20 square miles in the west-central part of the area. It is separated from the mesa by a belt of badly eroded Rough broken land, ranging from one-fourth mile to 1½ miles in width, but the slopes of the mountain proper consist principally of precipitous masses of rock outcrop, almost entirely devoid of vegetation. The elevations range from 700 to 1,000 feet above the adjoining plain, or from 1,150 to 1,360 feet above sea level. This range is practically continuous with the Palo Verde Mountains on the south, being separated from them only by a narrow gorge now occupied by the Niland-Rannells Road. At this point the mountains narrow down to little more than 1 mile in width, and for about 6 miles the range continues southward as a high, narrow ridge, widening out in an east-west direction along the south side of the area surveyed. On the west the precipitous slopes are bordered by a narrow strip of badly eroded lands that merge into steep, stony fans leading down to the Chuckawalla Valley on the west. East of the Palo Verde Mountains, along the south side of the area surveyed, is a maturely eroded, excessively stony section, covering 25 to 30 square miles, which is entirely unfit for agriculture.

Aside from a very small section between the Ironwood and Mule Mountains, which has interior drainage into the Chuckawalla Valley, all of the drainage of the Palo Verde area is toward the east into the Colorado River. Although this is a stream of rapid flow, its waters are so heavily charged with sediment that deep deposits of silt have been left along its course, with the result that the river now flows

upon a ridge varying from slightly above to 11 feet or more above the adjacent valley.

Although there was a thriving mining town on the river more than 60 years ago, the area surveyed remained practically uninhabited, except for a few people on the "Blythe Estate," until after 1900. Even for 7 or 8 years after the beginning of the present century settlement was very slow, the beginning of active growth dating back only about 15 years. At the present time settlement is confined entirely to the irrigated valley, although formerly a number of homesteaders lived on the mesa a sufficient length of time to obtain patents to the land. The early population consisted almost entirely of native white settlers, who took up homesteads or desert claims, or purchased land which had previously been proved upon under desert claims. While most of the early settlers came from other parts of California, it was not long before practically every State was represented in the population. Although a large proportion of the present population is native white American, there are considerable numbers of Negroes, Mexicans, and a few Japanese, Hindus, and Indians. According to local estimates, the present population of the valley is about 7,000, all of which is classed as rural. Blythe, the principal town, had, according to the census, a population of 1,622 in 1920. Ripley, in the south-central part of the valley, has an estimated population of about 500, and Fertilla and Palo Verde are small settlements in the north and south parts of the valley, respectively. At the present time practically all the population is confined to the northern two-thirds of the valley.

Transportation facilities are good in the north half of the area. A branch of the Atchison, Topeka & Santa Fe Railway, extending south from Rice on the Phoenix Branch of this system, gives direct communication with Los Angeles and points east. This road, entering the area near the northwest corner, crosses the northern part of the mesa and then extends south through the center of the valley to Ripley. Excepting a small section in the extreme south end of the Palo Verde Valley, no point within the valley is more than 5 miles from a shipping point.

The country road system throughout the valley is adequate for the present distribution of the population. Where the country is settled there is a road on nearly every section line, although many of these receive but little attention and are in poor repair. The roads across the mesa are usually about the average for desert roads, the 93-mile highway from Blythe to Mecca being the most traveled. During the last winter (1922) surveys were made for the construction of a paved State highway connecting these two towns. There are a number of schools conveniently located within the valley, and the telephone is in general use, although telephonic communication has not yet been provided with outside points.

Blythe is the principal local market. The cattle, hogs, and dairy and poultry products find a ready market in Los Angeles, while cotton and truck crops are shipped to eastern markets.

CLIMATE

The Palo Verde area is situated in the inland desert region of southern California. Being separated from the Pacific Ocean by a succession of desert valleys and arid mountain ranges, it is effectually shut off from the moderating influence of the sea, and the winds drifting inland from it are robbed of their moisture to such an extent before reaching this area that they pass over the region as hot, dry winds, capable of absorbing moisture rather than dispensing it. The climate, therefore, is decidedly arid. Aside from its dryness, the chief characteristics are the long, intensely hot summers, mild winters, low relative humidity, high rate of evaporation, and large proportion of sunshine.

The records of the Weather Bureau station at Blythe, Riverside County, show that the rainfall varies from 1.82 inches for the driest year (1917), to 6.64 inches for the wettest year (1918), with a mean annual precipitation of 4.26 inches. This usually comes in the form of hard rainstorms separated by long intervals without a trace of rain. Because of the uncertainty of its occurrence, it is of little use as a complement to irrigation. The spring and early summer months are always dry, the mean rainfall for March, April, and May being only 0.35 inch.

The summers are long and hot, temperatures of 100° F. or higher being recorded for every month from March to October, inclusive. A maximum temperature of 121° F. has been recorded for both May and June, while during July, August, and September the maximum temperatures have ranged from 115° to 119° F. During each of the winter months the mercury has risen to 87° F. or over, the mean for this season being 51.9° F. Throughout the summer months the nights are also relatively hot, although the dryness of the atmosphere renders the heat much less oppressive than in sections where the humidity is greater. The lowest temperature recorded is 5° F., occurring in January.

The average date of the last killing frost in spring is March 2 and that of the earliest in the fall November 8. Frosts may be expected, however, at any time between the middle of October and the first of April. Records show that frosts have occurred at Blythe as early as October 18 and as late as April 2. Damaging frosts are, however, of rare occurrence, vegetables being grown throughout the winter months, the more tender ones, such as cantaloupes and tomatoes, being protected for a time by oiled-paper coverings. The climate is exceptionally favorable for the winter pasturing of cattle, sheep, and hogs on alfalfa and grain. The first cutting of alfalfa is usually made about the first week in April.

The following tables compiled from records of the United States Weather Bureau show the normal monthly, seasonal, and annual temperature and precipitation at Blythe and Calexico, the latter situated in the Imperial Valley on the international boundary.

Normal monthly, seasonal, and annual temperature and precipitation at Blythe, Riverside County

[Elevation, 268 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1917)	Total amount for the wettest year (1918)
	°F.	°F.	°F.	Inches	Inches	Inches
December	50.8	91	11	0.49	0.00	1.02
January	50.0	89	5	.71	.79	.93
February	54.9	87	19	.71	.01	.07
Winter	51.9	91	5	1.91	.80	2.02
March	60.2	100	24	.24	.00	.75
April	67.8	106	32	.10	.42	T.
May	73.4	121	34	.01	T.	.00
Spring	67.1	121	24	.35	.42	.75
June	84.1	121	42	.05	.00	T.
July	90.3	119	52	.41	T.	T.
August	88.7	118	49	.34	.60	.53
Summer	87.7	121	42	.80	.60	.53
September	81.9	115	41	.68	T.	2.78
October	68.5	107	29	.18	T.	.07
November	58.1	96	17	.34	.00	.49
Fall	69.5	115	17	1.20	T.	3.34
Year	68.7	121	5	4.26	1.82	6.64

Normal monthly, seasonal, and annual temperature and precipitation at Calexico, Imperial County

[Elevation, 0 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1905)
	°F.	°F.	°F.	Inches	Inches	Inches
December	52.9	89	25	0.30	0.00	0.54
January	53.4	85	21	.55	T.	1.50
February	58.0	88	28	.57	.00	3.76
Winter	54.8	89	21	1.42	T.	5.80
March	63.4	100	32	.34	.04	.91
April	69.8	104	41	.09	.00	.50
May	74.6	116	41	.06	.00	.00
Spring	69.3	116	32	.49	.04	1.41
June	84.2	117	54	.02	.00	.00
July	89.6	117	59	.07	.08	.03
August	89.2	117	55	.53	T.	.00
Summer	87.7	117	54	.62	.08	.03
September	83.4	110	50	.15	.52	.13
October	72.4	106	36	.13	.00	.00
November	61.4	99	28	.29	T.	1.96
Fall	72.4	110	28	.57	.52	2.09
Year	71.0	117	21	3.10	.64	9.33

[1] Length of record, 15 years.

From the above tables it will be seen that the range in temperature at Blythe is somewhat greater than in the Imperial Valley, the minimum at Blythe being 5° F., whereas 21° F. is the coldest recorded at Calexico. The average length of the growing season at Blythe is 251 days; but while this is nearly two months shorter than that of the Imperial Valley, it is sufficient to allow the growing of a wide range of crops.

Owing to the large number of days of intense sunshine and the low relative humidity of the atmosphere, evaporation is very rapid, making frequent irrigations necessary on most soils for best results. From measurements made by the California Development Co. in the Imperial Valley from 1904 to 1906, inclusive, it was found that the annual evaporation from a water surface was 6.73 feet.

The prevailing direction of the winds is from the west. During the spring months winds are quite common and sometimes do a little damage by drifting the lighter textured soils. There are very few cloudy days, and fog, snow, and hail are practically unknown in the area. The rainfall is so slight that no agriculture is successful without irrigation.

AGRICULTURE

The first attempts at agriculture in the Palo Verde area were made in the late seventies, when 40,000 acres were acquired in one tract under the "swamp and overflow" act. At this time the thriving mining town of Ehrenberg, on the Arizona side of the Colorado, had reached a population of some 5,000 people and had started on its decline to the abandoned town site of to-day. For several years the Butterfield stage route had crossed the river at this point; but with the completion of the Southern Pacific Railroad, in 1879, the stage route was discontinued, and thereafter the principal means of communication was by the infrequent river boats from Yuma. Although during this period an excellent intake was established at the site of the present one and a small acreage placed under irrigation, development soon ceased and for the next 25 years the project remained at a standstill and the only use made of the valley was the grazing of cattle on the open range. In 1904 the 40,000 acres known as the "Blythe Estate" was sold to the Palo Verde Land & Water Co., and a few settlers began to arrive in the northern part of the valley. In the meantime several farms had been developed in the vicinity of Palo Verde, in the south end of the valley, but during the summer of 1905 development in this section was checked by a widespread flood that did considerable damage to buildings and crops.

In 1908 the town of Blythe was established, the Palo Verde Mutual Water Co. organized, and important extensions begun on the canal system of the valley. During this year the sale of water stock reached and for the next four years remained at 30,000 shares, each share of stock representing 1 acre of land. However, only a small proportion of this acreage was under irrigation at this time. In 1910 Government lands outside of the Blythe Estate were opened to entry under the homestead and desert acts, and soon thereafter a rapid immigration of settlers took place. During these years the agriculture was confined principally to the raising of alfalfa, milo, and barley, with potatoes, sweet potatoes, and such garden crops as

were used at home. Cotton was not grown commercially until 1911, when a total of 277 bales was produced. In general, therefore, it may be said that active agricultural development in the Palo Verde Valley extends over a period of less than 15 years. In fact, rapid development in the valley did not begin until about nine years ago, or until the fall of 1913.

The trend of development during the next few years is probably well indicated by the following table showing the total production of cotton:

Production of cotton in the Palo Verde area, 1911 to 1916, inclusive

Year	Production	Year	Production
	Bales		*Bales*
1911	277	1914	3,259
1912	649	1915	1,631
1913	1,550	1916	[1] 5,000

[1] Estimated.

During this period the only means of marketing products outside of the valley was by hauling them by teams to the Santa Fe Railway, 42 miles to the north, or to the Southern Pacific Railroad, more than 60 miles to the south. Yet in spite of this handicap not only cotton but also a number of carloads of hogs, and some wheat, butter, and poultry were marketed at a profit. In August, 1916, the development in the valley received its greatest impetus by the completion of the California Southern Railroad to Blythe, which gave it direct connection with the Santa Fe Railway on the north.[1] Since that time the acreage under cultivation has steadily increased, except in 1921 when, following a decrease in the price of cotton, the acreage of this crop was reduced more than 8,500 acres, making the total area under cultivation for this year more than 3,000 acres less than in 1920.

The following table compiled from information furnished by officials of the Palo Verde Mutual Water Co., gives the acreages devoted to the various crops and the total acreages cultivated in 1920 and 1921.

Area under cultivation in the Palo Verde area in 1920 and 1921

Year	Cotton	Alfalfa	Grains	Miscellaneous	Total
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
1920	23,438	4,684	1,554	1,042	30,718
1921	14,896	5,389	5,024	2,067	27,376

At the present time the agriculture of the Palo Verde Valley consists of the growing of cotton for sale, the raising of alfalfa and grain hay for feeding work stock, cattle, and hogs, and to a less extent, the production of truck crops for market, and for home use.

[1] The California Southern Railroad is now a part of the Atchison, Topeka & Santa Fe Railway.

Dairying and poultry raising are locally important, and a large acreage has recently been planted to grapes.

For the last several years cotton has occupied the principal acreage, nearly three-fourths of the total irrigated acreage being devoted to this crop in 1920, while cotton and alfalfa combined occupied nearly 90 per cent of the total. In 1921 cotton occupied more than one-half of the total acreage. Although long-staple cotton has been tried in the valley, it has never occupied a prominent place, and at the present time the entire acreage is of short-staple varieties. In common with all the other crops of the area, this crop is grown only with irrigation. It is remarkably free from pests, and because of the favorable climatic conditions at harvest time, a clean, high-grade fiber is obtained. The yields vary considerably with the character of the land, especially as regards alkali, and the efficiency of cultivation and irrigation. Well-farmed lands are yielding an average of 1 bale or more per acre, although the average for the entire valley is about three-fourths bale per acre. The crop is grown on all of the various soils of the valley, but the largest acreage is on the heavy-textured types of the Holtville and Imperial series. Some of the largest yields have been obtained on light-textured soils that have been in alfalfa for several years.

In preparing land for cotton, the fields are usually plowed dry in February or March. If the soil is heavy textured, the plowed fields are irrigated and as soon as the soil is dry enough it is disked and thrown up into ridges about 4 feet apart. The seed is drilled along the top of the ridges, which are smoothed down with a harrow just before planting. Sometimes the fields are irrigated by running water down the furrows just prior to planting, and sometimes the irrigation is deferred until after the seed is in the ground. The latter practice is usually followed where difficulty is had in getting a stand due to high concentration of alkali near the surface. The number of irrigations varies greatly with the character of the soil and the position of the water table. On light-textured soils with a shallow water table good yields have been obtained with only 2 or 3 irrigations, while some of the heavier textured soils are irrigated 10 or 12 times during the growing season. Planting is usually done during the latter part of April and the picking begins early in September and continues, in some cases, until well into February.

Alfalfa is the second crop in importance and its acreage is rapidly increasing. The crop is grown principally to supply hay for work stock on the farms. The winter pasturing of beef cattle on alfalfa has been carried on in a small way and the crop is of importance also as a possible basis for dairying. Although it makes little growth during the winter months, the fields furnish pasture throughout the entire year and thus reduce the ordinarily large expenditure for winter feeding. Alfalfa is usually cut five to seven times during the season, and under favorable conditions yields about 1 ton per cutting. In addition to the winter pasturage the average annual yield for the valley is probably about 5 tons per acre. The first cutting usually is made early in April, and the last in October or November.

Alfalfa seed is being harvested from a relatively small acreage as a money crop, with excellent results. As the seed crop requires about the same length of time to mature as does two crops of hay, the

second cutting is usually dispensed with and the seed crop harvested early in July. In a few instances, two seed crops are obtained, in July and September, but more often, only one. Under the present favorable conditions of soil moisture this is a promising crop, as the yields range from 300 to 500 pounds per acre, and the seed is generally in demand at good prices. Only the common (Chilean) variety is grown.

Although alfalfa is grown on practically all the soils of the valley, it thrives best on medium-textured to light-textured soils overlying well-drained, permeable subsoils. Excepting those areas where the water table is variable and too shallow for the crop, these favorable conditions are generally present, and it is probable that there is no other crop to which the soils of the valley are more generally adapted.

The growing of grain and grain hay is becoming of greater importance. According to information given by the Palo Verde Mutual Water Co., there were 1,554 acres in grains in 1920 and 5,024 acres in 1921. During this year the acreage in grains of all kinds was practically the same as that devoted to alfalfa. The principal grain crops are barley, milo, and wheat. Barley occupies somewhat the largest acreage. In the past it has been grown principally in connection with alfalfa for hay and winter pasturage, but there is an increasing acreage being harvested for grain. Seeding is done in the fall and the hay crop is usually removed early in April, after which, if the crop has been grown alone, the land is prepared and planted with cotton or with milo or one of the other nonsaccharine sorghums. Most of the barley is grown on the Holtville and Imperial soils of medium to heavy texture, except in those instances where it is sown with alfalfa for the purpose of increasing winter pasturage or the first cutting of hay. Because a hay crop can usually be harvested before the spring overflows, it is about the only crop which has been grown in the past on some of the low-lying areas subject to annual flooding.

Wheat occupies only a small acreage in the Palo Verde Valley. It is grown mostly with alfalfa for hay, although there is a small but increasing acreage harvested for grain. As is the case with barley, wheat is sown in the fall, mostly on heavy-textured soils. It is harvested in April or May, depending on whether it is cut for hay or for grain. Large yields are reported where the soils are free from alkali, but wheat is apparently more susceptible to adverse soil conditions than is barley, and the average yields for the entire valley are not such as to warrant an extensive acreage.

Milo is an important grain crop, although the acreage grown is insufficient to supply the home demand for feeding work stock and hogs. The crop is usually sown from the latter part of May to July after cotton or a winter crop of barley or wheat, and is harvested from the latter part of September to November. The crop is harvested either with a corn harvester, shocked, and fed in that condition or the heads are removed from the standing stalk by hand. Kafir and feterita are also important crops used for feeding livestock on the farms, but the quantity of grain feed is not sufficient and considerable quantities are shipped in.

Among the truck crops that are just beginning to be grown commercially are cantaloupes, lettuce, watermelons, tomatoes, potatoes, and sweet potatoes. During the present year (1922) these crops were planted in sufficient acreage to demonstrate their adaptability to the soil and climate of the valley. The total acreage, however, was comparatively small, only a few hundred acres being planted to all of these crops combined. All the truck crops are planted in the winter, the cantaloupes, watermelons, and tomatoes being protected by oiled-paper coverings during the few weeks that frosts are likely to occur. The present season, lettuce was planted about the last week in January, the planting being so timed that the crop would mature early in May, or following the last shipments from the Imperial Valley. Plate XV, Figure 2, gives an idea of the scale on which lettuce is grown. This crop is grown both on light-textured and heavy-textured soils, but the other truck crops are confined to areas having sandy or easily cultivated surface soils. Practically all of the truck crops are grown in the northern and central parts of the valley, a number of newly set vineyards being interplanted with one or another of these crops.

Although fruits of various kinds have been grown for home use for several years, there has been almost no commercial planting until the present year, when nearly 1,000 acres were set in grapes. The largest acreage is on light-textured soils in the northern part of the valley, but there are new vineyards in other parts of the valley and on soils of rather heavy texture. The Malaga is the principal variety, with a small acreage of Sultanina (*Thompson Seedless*). Grapes are planted exclusively for table use. They ripen early in July, which is somewhat earlier than the beginning of shipment from other sections of the State.

Among the other fruits which appear most promising for the Palo Verde Valley are apricots and pomegranates. Apricots ripen early in May and are among the first in the State to reach the markets. As yet, however, the acreage of these fruits is small.

The dairy industry and the raising of beef cattle are developed only in a small way. The dairy herds consist chiefly of grade Holstein and Jersey animals; the beef cattle are mainly Hereford. A few years ago dairy products were manufactured and shipped to outside markets, but during the last few years almost no shipments have been made. At the present time a creamery is being opened at Blythe and provision is being made for increasing the number of dairy cows. A few beef cattle are shipped into the valley each fall from Arizona for winter grazing on alfalfa. Considering the marked advantages for this type of agriculture in the valley, it would seem that the number is far less than the number that could be profitably grazed. There are also comparatively few hogs in the valley, although the conditions are exceptionally well suited to hog raising. The most popular breed is Duroc-Jersey. Stock of all kinds can be grazed the year round and the climate is such that expensive housing is unnecessary. In addition to alfalfa the beef cattle are fed cottonseed products produced in the valley. The hogs are fattened largely on home-grown milo and barley.

The farmers of the Palo Verde Valley recognize that the medium and light-textured soils with permeable subsoils are best suited to

the production of alfalfa and that the sandy soils are the earliest and best suited to early truck crops. They consider the heavy-textured soils well adapted to cotton, milo, barley, and wheat, but poorly suited to alfalfa, except where the subsoils are permeable and well drained. The soils of the Rositas and Meloland series, where the clay in the subsoil of the latter occurs at considerable depths, are considered well suited to the production of grapes, apricots, and all crops whose success is more or less dependent on early maturity.

Topography has had the greatest influence on the distribution of crops in the area, as agriculture can be conducted in this region only with irrigation, and only the valley parts of the area have water available for this purpose. For this reason about two-thirds of the area mapped, occurring on the mesa and including scattered mountain masses, is entirely undeveloped. Certain areas within the valley having a dunelike topography are not in use because of the high expense of leveling. In the past little attention has been given to the adaptability of soils to the various crops grown, cotton having been grown generally on all of the soils in the valley. During the last two years, however, there has been a tendency to restrict this crop to the heavier soils and to devote the lighter textured soils to alfalfa.

The agriculture of the Palo Verde area is of the year-round type, some of the most profitable crops being grown during the winter months. The trucking industry is conducted almost entirely during the winter and spring, most of the planting being done in January and the harvesting in May and June. The first cutting of alfalfa is usually made about the first week in April and the last in October or November, after which the fields furnish more or less winter pasturage for beef cattle, dairy cattle, and hogs. Cotton occupies the land from the latter part of April until October or November, although the picking of some fields may not be completed until February.

Owing to the fact that the valley has but recently been settled and that little protection against cold need be provided, many of the dwellings are cheaply constructed and of a temporary character, though there are a few permanent and substantial houses of recent construction. (Pl. XVI, fig. 1.) There are few barns, and most of these are only temporary sheds. The work stock used consists of small to medium-sized horses, but there is an increasing volume of work performed with tractors, and modern implements and labor-saving devices are in use on nearly every farm.

Up to the present time little attention has been given to following a definite rotation, cotton having occupied some of the soils continuously since they were first developed. In some instances cotton is followed by milo planted in June or July, and some fields are prepared in the fall immediately after cotton picking and sown to winter barley or wheat. A few farmers after harvesting alfalfa for several years make use of the alfalfa sod for growing cotton, although this practice is not common, and many of the fields originally seeded to alfalfa are still producing that crop.

Practically no commercial fertilizer is used in the Palo Verde Valley. All available supplies of barnyard manure, however, are carefully conserved and applied to the land, mainly to those areas

PHOTO BY UNIV. OF CALIF.

FIG. 1.—ESCARPMENT OF THE MESA IN BACKGROUND, AND SECTION OF THE ALLUVIAL VALLEY (FOREGROUND)

The fields are of the Meloland very fine sandy loam, stratified phase; the crop is cotton

FIG. 2.—FIELD OF LETTUCE ON THE IMPERIAL SILTY CLAY LOAM, NEAR FERTILLA

NO. 11330

FIG. 1.—PERMANENT FARM DWELLING OF THE BETTER TYPE, ADAPTED TO THE CLIMATIC CONDITIONS OF THE AREA

The most of the present farm buildings are of only temporary and unsubstantial character

PHOTO BY UNIV. OF CALIF.

FIG. 2.—SHRINKAGE CRACKS AND SUN-BAKED, COMPACT SHALY STRUCTURE IN RECENTLY DEPOSITED MATERIAL OF THE HOLTVILLE CLAY

in which alkali is troublesome. In addition, sweet clover is sowed by many as a winter cover crop to be plowed under in the spring.

Except during the hottest months of the summer, when hired help is scarce, the supply of labor is adequate, as during the rest of the year many itinerant laborers are attracted to the valley by the mild climate. Most of the laborers are white American and are efficient. There are some Negroes and Mexicans and a few Indians in the valley, most of the last being employed in constructing the levee and in maintenance work on ditches. During the present season most of the labor employed during the month of May in harvesting and packing lettuce was imported from the Imperial Valley, where the winter months were spent in the same character of work. Much of the cotton is picked by Negroes and Mexicans. When employed by the month laborers are generally paid $75 to $100 a month. Day laborers receive $2 to $2.50 a day and board. Cotton is usually picked on a piece basis the rate ranging from $1.50 to $1.75 a hundred pounds, depending on the character of the crop.

Most of the farms range from 40 to 160 acres in size, although there are some containing 2,000 acres or more. Excepting the large holdings, the average size of farms in the Palo Verde Valley is probably around 100 acres. The larger farms are devoted almost entirely to alfalfa, grain, and stock raising.

No definite information is available concerning the proportion of farms in the valley operated by owners. A rather large percentage of them, however, are said to be owned by nonresidents who lease them usually on shares, the owner receiving one-fourth and the renter three-fourths of the crop. Under this provision the owner furnishes only the land, taxes, and water assessments, and the renter the equipment, seed, and labor necessary to grow the crop. Some of the larger farms are operated by salaried managers.

Well-developed lands in the Palo Verde Valley range in value from $150 to $200 an acre. Much of the undeveloped land can be bought for $25 to $50 an acre, although some tracts are said to be held at $60 to $125 an acre, depending on location. The mesa lands which lie considerably above the present supply of irrigation water are not being sold, but they are said to be held at a comparatively low figure. Considering the fact that agriculture can be conducted in the Palo Verde Valley throughout the entire year, the price of land compares very favorably with prices in other irrigated sections. Less than one-half of the valley has been irrigated, and there are apparently excellent opportunities for further settlement.

SOILS

The Palo Verde area lies in the southwest desert region. It is formed partly of the recent-alluvial lands along the west side of the Colorado River, known as the Palo Verde Valley, and partly of the extensive desert extending westward from the valley to the Chuckawalla and Eagle Mountains east of Mecca. About one-third of the area mapped lies in the irrigated alluvial valley; the rest is desert mesa 100 feet or more above all present sources of water for irriga-

tion. Surrounded by barren mountains, with a climate of high temperatures, almost constant sunshine, and a rainfall which sometimes is less than 2 inches for the year, the soils have weathered under typical desert conditions, a fact which is plainly reflected in their physical and chemical characteristics. In more humid regions there is rarely an excess of soluble materials in the soil, as the rainfall is sufficient to wash them away as rapidly as they go into solution, but here, with scant rainfall, the soils are unleached and still retain quantities of mineral salts readily soluble in water. Here, too, recently deposited clays soon become hard and shalelike, resembling soils of mature age. (Pl. XVI, fig. 2.) In the desert parts of the area, where the soils are considerably older, surface crusts of various thicknesses are nearly everywhere developed, lime and various soluble materials are usually abundant, and definite concentrations of lime carbonate commonly occur in the subsoil. Under the influence of the intense sunshine the cobbles and gravels common on the surface have become sun-bronzed and polished, having a metallic luster which is frequently remarkable.

According to their profile characteristics, the soils of the area belong in three groups: (1) Soils with well-developed desert profiles occupying the uplands or mesa, (2) soils without profiles except those due to the conditions under which the material was deposited from flood waters, and (3) wind-laid soils. The first two groups are the more important.

The first group comprises strictly desert soils, or soils displaying profiles characteristically formed by weathering in place under pronounced arid conditions. Some of them are maturely weathered and by the development of surface crusts, by distinctly calcareous partly cemented layers in the subsoil, and, in some instances, by the translocation of clay from the surface to an underlying layer, they differ markedly from the more recent, lower lying soils of the valley. They are fairly uniform in topography, occupying nearly level terrace positions or old alluvial fans at the foot of the mountains. Most of the material has apparently been derived by wash from the near-by mountains, although there are a number of high terraces and smoothly rounded ridges on which the material to many feet in depth consists almost entirely of highly polished, water-rounded gravels, the source of which is not now evident. All the soils contain varying quantities of gravel, and for some distance out from the mountains the content of stones is sufficient to render the land unfit for cultivation. (Pl. XVII, fig. 1.) The stones differ widely in kind, but the greater proportion consists of quartzite. Some fragments of basalt and other basic igneous materials appear near the mountains. The rocks in the hills are apparently rich in soluble mineral constituents, as deposits of gypsum and other salts are common in some localities and most of the soils on the higher fans are strongly impregnated with alkali. On the basis of difference in color, lime content, and in profile the soils of this group may be arranged in two series, namely, the Tijeras and Superstition. Associated with these are extensive areas of two types of nonagricultural land, Rough stony land and Rough broken land, the latter consisting principally of areas of the Tijeras and Superstition soils of rough topography. From the standpoint of agriculture, the soils of this

group are of little present importance, as they lie well above the irrigation facilities and are entirely undeveloped.

Of all the soils mapped in the area, the Tijeras soils are probably the oldest. In these weathering has developed definite layers in the soil profile which mark them as typical desert soils. These layers, however, vary considerably within the types of the series both as to thickness and order of arrangement. In places some of the layers are only a few inches thick; in near-by areas the corresponding layer may attain a thickness of 2 feet. The prevailing profile, however, in the Palo Verde area is as follows:

The top layer consists of a desert crust 1 to 4 inches thick, of pinkish-gray to pale-red compact, highly calcareous material. Next below is a layer of pale-red or pinkish-gray, compact material containing a quantity of gray, nodular, or angular particles of lime. Below this, at depths varying from 5 to 8 inches, there appears a third stratum consisting of a very compact, or loosely cemented, pale-red or purplish-red, usually heavier textured material, high in lime carbonate and other soluble salts. The limy material increases downward to an average depth of about 24 inches, below which the content of lime gradually diminishes until at depths varying from 30 to 40 inches it ceases to be visible. Here a fourth layer consisting of purplish-red to pale-red loamy sand or sandy loam begins, which after persisting for 6 or 8 inches, passes into pale-red, loose, medium textured sand. In all cases in the Palo Verde area the immediate surface is covered with either highly polished, water-rounded gravels, or subangular and angular rock fragments. Gravel and bowlders of various sizes also commonly appear throughout the soil profile, sometimes firmly cemented in finer material, but in places loose, though usually coated with lime. In this area the content of stones is sufficient seriously to interfere with, or in places to preclude cultivation. Surface drainage is usually excessive, and most of the rain that falls on the types either flows away without leaving a trace or evaporates, very little entering the compact, calcareous horizons beneath the surface. The greater part of the area of these types is either bare of vegetation or is sparsely covered with creosote bush and desert weeds. Three types, a stony sandy loam, sandy loam, and a gravelly loam are mapped in the Palo Verde area.

The Superstition soils differ from the Tijeras mainly in being less red in color, less compact in structure, and somewhat lower in lime.

The typical profile consists of (1) a desert crust, one-fourth inch to 2 or 3 inches thick, composed of light-gray, or light brownish gray, tinged with red, slightly compact, calcareous material containing a relatively large proportion of coarse sand and fine gravel; (2) a layer of light-gray, of light grayish brown, or faintly reddish brown, moderately compact material containing small angular and concretionary particles of lime, the content of which increases downward to 30 or 40 inches; (3) a layer of pale-pinkish or grayish-brown, loosely cemented material usually of light texture, containing a large quantity of nodular particles of lime and, in rare instances, thin fragments of hardpanlike material; and (4) a light-gray or pinkish-tinted, loose, coarse-textured material containing varying quantities of coarse sand and gravel. (Pl. XVIII, fig. 1.) As occurring in the Palo Verde area, the greater part of the Superstition

soils have a somewhat looser structure than as above described, the changes due to the normal processes of soil weathering being much less marked, especially those due to concentrations of lime. The material is also of redder color than in areas mapped in previous surveys and the soils represent a gradation between the typical gray Superstition and the pale-red soils of the Tijeras series. Many of the areas consist of pale reddish brown loose, porous sand, showing little variation to a depth of 6 feet or more.

The Superstition soils occur on the level to gently sloping mesa and lower parts of old alluvial fans. They are commonly separated from the mountains by the more maturely weathered types of the Tijeras series. The soils are well drained and, with few exceptions, free from alkali. The native vegetation consists of a rather vigorous growth of creosote bush (*Covillea tridentata*), locally known as greasewood; hop sage (*Grayia spinosa*); and other small desert shrubs and plants.

The second group, recent-alluvial soils, is of considerable agricultural importance. These soils occupy a semicircular basin, the Palo Verde Valley, about 30 miles long and averaging about 7 miles wide, lying along and west of the Colorado River. The greater part of this basin is below the level of the river, so that unless protected by a levee it would be subject to periodic flooding. In fact, it is due to the successive floods and the frequent shifting of the river back and forth across the valley that the most of the soils of this section have been formed, the river being noted for the vast quantities of sediment it carries and deposits along its course. Plate XVII, Figure 2 illustrates this. It is variously estimated that in the Imperial Valley, in which sediments of similar source and character occur, these deposits are 1,000 to 1,800 feet thick, and in the present survey the deepest wells have failed to reach bedrock. These deposits, although of comparatively recent age, have suffered considerable modification since they were laid down, and most of the heavier deposits, when thoroughly dry, have the compact, shaly structure so frequently found in soils of mature age. Although the material of the entire soil profile is always calcareous, there is, however, never the pronounced concentration of lime so characteristic of the older desert soils, nor any trace of cementation in any part of the profile. Both the soil and subsoil may be of the same general character, or the subsoil may be heavier or lighter textured than the surface soil, or, as is frequently the case, there may be distinct stratification with occurrence of materials of widely varying texture. For the most part the materials represent water-laid deposits from the Colorado River, although there are considerable areas of light-textured soils which have probably been derived in part from materials blown into the valley from the higher lying fans and mesa. The lighter textured types of the Colorado River deposits also have all been more or less modified by winds. The soil materials giving soils of this group have come originally from a variety of rocks. Differences in color, structure, mode of formation, and character of subsoil materials have given rise to three series of soils—the Carrizo, Imperial, and Holtville. In addition to these there are mapped two types of undifferentiated materials.

The soils of the Carrizo series are of light-gray to light brownish gray, or light grayish brown color, the finer material being pre-

dominantly brown and the coarser material, in which quartz fragments predominate, being gray. They are of open, pervious structure, low in organic matter, and in many areas contain stone and gravel. The subsoil is of similar color, friable, permeable, and consists of material similar in texture and structure to the surface soils or of but imperfectly assorted deposits in which sand or gravelly materials predominate. The materials are unweathered and unleached and are usually only mildly calcareous, the lime being quite uniformly distributed through the soil profile. They are free from alkali. The series consists of recent stream-laid deposits, occupying desert stream channels and smooth to somewhat irregular or slightly eroded fan slopes. Drainage is excessive and the soils support only a sparse growth of desert shrubs, among the most common of which are creosote bush (*Covillea tridentata*) and the bright-green, shrublike tree known as palo verde (*Parkinsonia torreyana*), and an occasional mesquite tree. The series is represented in this survey by the sand type.

The types of the Imperial series, in the virgin condition, have light-brown or chocolate-brown firm to compact surface soils, underlain by a heavy-textured, compact subsoil to a depth of 6 feet or more. The bleached surface is sometimes a grayish brown or gray. In the virgin areas the subsoil has a jointed or shalelike structure. Both the soils and subsoil are calcareous, low in humus, and typically free from gravel or other coarse material. The Imperial soils have been formed from stream-laid sediments. The topography is nearly level, and the drainage is commonly poor. In most areas alkali is present in considerable quantities to a depth of 6 feet. The native vegetation is a thick growth of mesquite, cat's-claw, and other shrubs.

The surface soils of the types included in the Holtville series are light brown, chocolate brown, or purplish brown in color and firm and compact in structure, being identical in the surface layer with the Imperial soils. The difference between the two series lies wholly in the subsoil, which in the Holtville is light textured, and loose and pervious in structure. Normally it consists of rather light brown, light chocolate brown, or slightly reddish brown fine sand or fine sandy loam. The subsoil is calcareous, although in most areas somewhat less so than the surface soil. Like the Imperial soils, the Holtville soils are underlain by old stream-laid or lake-laid stratified deposits extending to undetermined depths. The surface soils are of stream-laid material. The areas have a flat and smooth surface. Drainage is only fairly well developed, but where the water table is sufficiently deep the permeable subsoil favors the downward movement of water. The surface soils usually contain moderate quantities of alkali, but the sandy subsoil is in most places free of injurious quantities of soluble salts. The native vegetation consists of mesquite, cat's-claw, cottonwood, and willow.

The third group of soils, occurring mainly in the valley, includes the more pronounced wind-laid soils grouped in the Meloland and Rositas series. These soils are rather extensive and occur principally in the northern and western parts of the valley as hummocks and dunes 3 to 20 feet in height. Dunesand, occurring on the mesa near the west boundary of the area, is closely related to the Rositas soils, the only difference being that the dunes are larger and more barren of vegetation and therefore more easily shifted by winds. Regard-

less of their origin, all of the light-textured soils have been redistributed by winds since their deposition, and it is probable that much of the material classed as wind-blown soils had its origin in the sediments of the Colorado River.

The types of the Meloland series have light-brown, light grayish brown, or light chocolate brown, mellow, micaceous soils, and a chocolate-brown or purplish-brown, compact, relatively heavy subsoil similar in all respects to the subsoil of the Imperial soils. In places the subsoil is slightly mottled with rusty brown. Both soil and subsoil are mildy calcareous, the subsoil normally containing somewhat more lime than the surface. In most areas the surface soil is free from alkali, but the heavy-textured subsoil generally contains moderate to large concentrations. The series is derived from wind-modified or wind-distributed materials, probably coming originally from alluvial deposits, overlying heavy, water-laid deposits similar to those giving the Imperial series. The topography varies from nearly level to hummocky or undulating, with here and there wind-blown hummocks 1 to 3 feet in height. The surface drainage is usually well developed, but underdrainage is variable, depending on the depth of the heavy, impervious subsoil. In the virgin condition the soils are covered with a growth of mesquite, creosote bush, and other desert shrubs.

Associated with the soils of the Meloland series and resembling them in surface features are the soils of the Rositas series. The Rositas soils, however, have a light-textured, pervious subsoil. The surface soil and subsoil consist typically of light grayish brown or yellowish-brown pervious materials, with a pinkish or purplish tint in many places. The entire soil profile is mildly calcareous and is open and porous. The surface material in the natural state, being almost entirely devoid of organic matter, is especially loose and incoherent and easily drifted. The surface soils consist of wind-blown deposits and the subsoils are of similar material or consist of stratified water-laid deposits. The topography of virgin areas is hummocky or dunelike, the mounds and dunes ranging from 3 to 20 feet or more in height. Drainage is good to excessive, and the soils are of rather low moisture-holding capacity. They are usually free from alkali.

In addition to the soils so far mentioned the area mapped includes narrow strips of Riverwash, coarse, stony or gravelly, nonagricultural material occurring along the desert drainage ways, and a miscellaneous group of overflowed, undifferentiated alluvial soils lying between the levee and the river.

Following the completion of the field work of this survey in May, 1922, the river broke through the levee and flooded about 35,000 acres in the south part of the valley. The first break occurred at Rabb Bend, 3 miles southeast of Blythe, followed, a few weeks later, by a second break at Hauser Bend. Coursing in a southwesterly direction, the crest of the flood passed through the town of Ripley, whence it followed the general course of the Laguna Palo Verde. This channel, however, was quite inadequate to carry off the water, for the volume was such that, excepting a few higher spots, practically all of the valley south of Ripley was under water from 1 to 4 feet in depth. With the subsidence of the flood, this part of the valley was covered with a fresh deposit of clay, silt, and very fine

sand, necessitating the remapping of the soils in this section during the fall of 1922.

There appears to have been little uniformity in the action of the flood, for in places formerly occupied by clay where the current was swift the surface is now covered with 4 feet or more of very fine sand, whereas in near-by areas on which backwater stood the land is buried under a fresh deposit of heavy silt or clay. The level of fields formerly irrigated was destroyed, miles of ditches and other irrigation structures were washed out or rendered obsolete, tools and farming implements were buried, and houses filled with sand. As the flood was confined to the south part of the valley, where a considerable proportion of the land has not yet been cleared, the damage was less than it would have been had it occurred in the older cultivated parts. At the time of the resurvey, the work of reconstruction had begun and it is probable that most of the fields will again soon be in cultivation. While the newly deposited soils bear a close resemblance to the Imperial and Holtville soils, they differ somewhat in color and are of more recent deposition. These are soils classified in the Gila series.

The types included in the Gila series consist of light-brown or slightly pinkish brown surface soils and a light-brown to chocolate-colored, irregularly stratified subsoil. In the heavier types the surface sometimes bleaches to a brownish gray or gray, but moist surfaces always show a decided brown, with a trace of pink, chocolate, or purple. Both the soils and subsoils are mildly calcareous and contain varying quantities of alkali. These soils are similar to the Imperial and Holtville series, but are distinguished from them by a somewhat lighter color and in being of more recent origin. As occurring in the present survey, the soils consist of materials deposited over types of other series during the flood of the Colorado River in the spring of 1922. The new material ranges from only a few inches to 3 or 4 feet in depth. Owing to its newness it is practically devoid of organic matter.

In the following pages the various soils are described in detail and their relation to agriculture discussed. The distribution of the soils in the Palo Verde area is shown on the accompanying map, and their actual and relative extent in the following table:

Areas of different soils

Soil	Acres	Per cent	Soil	Acres	Per cent
Superstition sand	63,424	23.4	Rositas very fine sandy loam	6,484	2.4
Rough stony land	29,056	10.7	Gila very fine sand	4,928	1.8
Rough broken land	22,976	8.5	Tijeras sandy loam	4,736	1.8
Tijeras stony sandy loam	22,784	8.4	Meloland very fine sandy loam	704	1.6
Alluvial soils, undifferentiated	16,384	6.1	Stratified phase	3,520	
Holtville clay	15,872	5.9	Dunesand	3,520	1.3
Superstition gravelly sand	11,968	5.3	Rositas fine sandy loam	3,392	1.3
Stony phase	2,496		Carrizo sand	2,752	1.0
Imperial very fine sandy loam	1,920	3.1	Imperial clay	1,216	1.0
Stratified phase	6,592		Stratified phase	1,216	
Holtville silty clay loam	8,192	3.0	Gila silt loam	1,856	.7
Holtville silty clay	8,192	3.0	Holtville silt loam	1,664	.6
Rositas fine sand	7,936	2.9	Tijeras gravelly loam	1,600	.6
Riverwash	7,872	2.9			
Imperial silty clay loam	1,152	2.7	Total	270,720	
Stratified phase	6,336				

TIJERAS STONY SANDY LOAM

The Tijeras stony sandy loam consists typically of a desert crust 2 to 4 inches thick of pale-red or pinkish, compact, highly calcareous sandy loam of relatively fine texture; a second layer of pinkish-gray, compact sandy loam partially cemented with lime and carrying a large quantity of angular gravel and larger stones; and a third layer of pinkish-gray, loose, porous, gravelly sandy loam or fine sandy loam extending to a depth of 6 feet or more. This lowest layer is exceedingly stony, and strongly calcareous, though somewhat less so than the material above. In places, the entire soil is a mass of angular cobbles and stones containing only a small percentage of fine material, and the surface is everywhere covered with angular rock fragments ranging from 3 or 4 inches to 1 foot or more in diameter. (See Pl. XVII, fig. 1.) All of the layers, except the porous deeper sandy loam, are strongly impregnated with soluble salts.

The Tijeras stony sandy loam is an extensive desert soil occupying a number of fanlike areas near the base of the mountains. In the northern and southern parts of the area surveyed the type is separated from the mountains by Rough broken land, which consists mainly of badly eroded areas of this type. The largest areas of the Tijeras stony sandy loam are associated with the Santa Maria Mountains in the northern part of the area, along the east and south sides of Ironwood Mountain west of Blythe, and bordering the Mule and Palo Verde Mountains in the southwest part of the area surveyed.

The topography ranges from gently sloping to rolling. Surface drainage is well developed but the underdrainage is inadequate. The greater part of the type is bare of vegetation, except for an occasional creosote bush, ocotillo, and small desert shrubs. Owing to its stony character, the type is entirely valueless for agriculture.

The following table gives the results of mechanical analyses of the surface soil, subsurface, and subsoil of this type:

Mechanical analyses of Tijeras stony sandy loam

[Fine earth]

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
575801	Surface soil, 0 to 4 inches	9.3	8.9	5.5	26.7	26.2	12.9	10.4
575802	Subsurface, 4 to 12 inches	14.3	9.0	5.3	22.8	20.6	18.8	9.3
575803	Subsoil, 12 to 36 inches	11.9	7.2	8.7	23.2	19.0	20.0	9.2

TIJERAS SANDY LOAM

A desert pavement of polished gravel covers the surface of the Tijeras sandy loam. Beneath this there appears a crust about 1 inch thick, of pinkish-gray sandy loam or fine sandy loam.

Below this is a layer about 4 inches thick, consisting of pale-red, or pinkish-colored, compact sandy loam containing a quantity of gray concretions and angular particles of lime carbonate or lime cemented material. At an average depth of about 5 inches this grades into a third layer consisting of very compact, or loosely

cemented, pale-red to purplish-red sandy loam, sticky when moist, but containing considerable medium and coarse sand and a large percentage of gray, nodular particles of lime. The concentration of lime increases downward to a depth of about 20 inches, below which it gradually diminishes until at 24 to 30 inches in depth lime particles are no longer visible. Here a fourth layer appears. This consists of purplish-red loamy sand which passes at an average depth of 48 inches into pale-red, loose, medium-textured sand. The material throughout the profile of this soil contains large, though variable, quantities of lime, and all the heavy-textured materials contain strong concentrations of alkali.

Owing probably to the high content of lime, and probably also to a high content of colloids, the three upper horizons are sticky when wet, bake upon exposure, and appear to be of much heavier texture than is indicated by the mechanical analyses.

The Tijeras sandy loam is an inextensive soil. It is confined to that part of the desert lying north of the Mecca-Los Angeles Highway. It occurs in long, narrow strips extending through areas of Superstition sand. As a rule, it roughly parallels the intermittent streams issuing from Ironwood Mountain on the west.

The topography is smooth, with a uniform, gentle slope, and the surface is entirely unmarked by drainage ways. Most of the rain that falls on this soil either flows away without leaving a trace on the hard gravelly surface or evaporates, very little entering the compact, calcareous horizon a few inches beneath the surface.

The Tijeras sandy loam is not farmed and has no agricultural importance. The greater part of it is either bare of vegetation or supports a sparse growth of desert weeds and creosote bush. All of it lies 100 feet or more above the present source of water. It is unsuited to dry farming, and even with irrigation, which would be expensive, much of it would be of little value for agriculture.

The following table gives the results of mechanical analyses of the surface crust, subsurface, soil, and subsoil of the Tijeras sandy loam:

Mechanical analyses of Tijeras sandy loam

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
575804	Surface crust, 0 to 1 inch	1.1	8.0	11.9	29.8	16.8	10.1	22.6
575805	Subsurface, 1 to 5 inches	2.7	13.1	23.4	21.8	11.6	10.0	17.8
575806	Soil, 5 to 24 inches	2.5	15.2	25.0	20.6	12.0	7.1	18.2
575807	Subsoil, 24 to 48 inches	2.3	21.4	24.1	24.9	8.1	5.6	13.4
575808	Subsoil, 48 to 72 inches	1.5	9.7	36.9	39.1	4.1	2.9	5.8

TIJERAS GRAVELLY LOAM

The immediate surface of the Tijeras gravelly loam is completely covered with a desert pavement of highly polished, waterworn gravel one-half inch to 3 inches in diameter. Underneath this the soil consists of pale-red to pinkish-gray, compact, gravelly loam about 8 inches thick, high in lime carbonate and soluble salts. Below this appears a layer of pinkish-gray to pale-red, compact, gravelly loam or heavy fine sandy loam containing a profusion of gray particles and vertical veins of limy material and a high con-

centration of soluble salts. The lime is in most places strongly concentrated about 2 feet below the surface and gradually diminishes in quantity upward and downward from this depth. The material is loosely cemented and difficult to penetrate with a shovel or pick, and when first broken up has a granular structure and the appearance of sandy loam. When moistened, however, the material becomes sticky and plastic and on redrying the clods become bricklike. A third layer appears at depths of 30 to 40 inches. This consists of pale-red, slightly compact sand, containing in the upper part small particles of lime carbonate. All the layers so far described carry a quantity of coarse waterworn gravel firmly embedded in the fine material, but gravel is especially abundant at about the third foot. At an average depth of about 56 inches there occurs a layer consisting of pale-red to brownish-red, loose, porous sand containing 25 to 40 per cent of fine, waterworn gravel. The material throughout the profile contains soluble salts, the heavier textured layers frequently showing a content of more than 3 per cent. The material throughout the profile effervesces freely in hydrochloric acid.

The Tijeras gravelly loam is confined to the desert parts of the area and is of small extent. The largest body, containing about 3 square miles, occupies a winding, irregular-shaped ridge on the Niland-Palo Verde Road about 4 miles west of Palo Verde. Conspicuous areas from one-fourth to one-half mile wide and 1 to 2 miles long occur in sections 5, 6, and 7 of T. 6 S., R. 22 E., and in sections 23, 24, 25, and 26 of T. 6 S., R. 21 E. A number of narrow strips lie along the Mecca-Los Angeles Highway 9 to 12 miles west of Blythe.

Owing to the thick covering of gravel on this soil the surface has been protected from erosion, the type typically occupying smoothly rounded ridges rising 20 to 30 feet above adjoining soils. Surface drainage is excessive, and owing to the impervious structure of the material the soil is rarely moistened to depths of more than a few inches even by the hardest rains. The type is nearly bare of vegetation. None of it is cultivated, and because of its gravelly nature, high content of alkali, and unfavorable structure and topography it is valueless for agriculture.

SUPERSTITION GRAVELLY SAND

The Superstition gravelly sand consists of a surface layer, 3 to 5 inches thick, of pinkish-gray, or pale reddish brown, compact gravelly sand, overlying a looser, more porous layer of similarly colored gravelly sand extending to an average depth of 20 inches. Below this, and extending to 72 inches or more in depth, is a pale-red, or light reddish brown, porous, medium to coarse sand, containing a large proportion of fine waterworn gravel. The gravel, which consists principally of granite and schist, in places forms much of the soil mass. Locally, this lower layer at a depth of 2 feet is quite compact and difficult to penetrate, although the entire type is too porous and leachy to have much value for agriculture even if the presence of gravel did not prevent. The entire profile is calcareous and free from alkali.

The total area of this type is about 12,000 acres. The largest areas are in the northwest part of the area and in the southern part north

of the Niland-Palo Verde Road. The surface of all areas is smooth and uniform and drainage is excessive.

None of this soil type is under cultivation, and most of it is non-agricultural. Except along the drainage ways, the native vegetation is more sparse than on the sand member of the series, and the type in general has the appearance of being very droughty.

Superstition gravelly sand, stony phase.—This phase differs from the typical gravelly sand in containing more large stones. The fine earth of the surface soil, to about 3 inches, consists of pinkish-gray or reddish compact gravelly sand or sandy loam. With this occur many angular bowlders 4 inches to 1 foot or more in diameter. The subsoil, to a depth of several feet, consists of gray, or grayish-brown, loose, porous, coarse sand in many places containing 80 to 90 per cent of fine gravel, cobbles, and small bowlders.

The extent of this phase is small. It is confined entirely to narrow strips on the lower parts of old alluvial fans. Areas are mapped in the northeastern, northwestern, and southwestern parts of the area. Two strips lie near the base of the northeast slope of Ironwood Mountain, and several smaller ones are mapped along the Blythe-Parker Road, and extending out toward the valley from the Santa Maria Mountains. The phase has no value for agriculture, owing to its large content of stones.

The following table gives the results of mechanical analyses of the fine earth of the surface soil, subsurface, and subsoil of the typical Superstition gravelly sand:

Mechanical analyses of Superstition gravelly sand

[Fine earth]

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
575815	Surface soil, 0 to 5 inches	6.4	9.9	20.3	34.8	19.8	3.9	4.9
575816	Subsurface, 5 to 20 inches	5.6	8.8	31.8	44.4	5.0	.1	2.7
575817	Subsoil, 20 to 72 inches	7.5	26.1	27.1	29.5	3.9	1.0	4.5

SUPERSTITION SAND

The upper layer of the Superstition sand consists of 2 or 3 inches of pinkish-gray or light pinkish brown, slightly compact, calcareous sand, containing a relatively large proportion of coarse sand and fine gravel. Below this appears a layer of grayish-brown or faintly reddish brown, moderately compact sand containing numerous small particles of lime carbonate, the content increasing with depth. At depths of 25 to 40 inches below the surface appears a third layer consisting of pale-red or pinkish-brown, loosely cemented sand containing a large quantity of nodular particles of lime carbonate and, in rare instances, thin chips of hardpanlike material ranging from one-half inch to several inches across. True lime hardpan, however, is not developed in any of the type, and the degree of concentration of lime varies greatly within short distances and at different depths apparently being greatest at about 40 inches. Below this the quantity gradually diminishes, and the material grades at about 60 inches

into reddish-brown or pinkish, loose, medium to coarse sand carrying varying quantities of gravel.

The above description refers to those areas well back on the desert, where the soil is most mature and most nearly typical of the established series. This description fits only a small proportion of the type mapped as Superstition sand in the present area. In the greater part of the type the changes due to soil-forming processes are much less marked. This difference is sufficient to result in an important variation, if not phase, of the type.

A study of this phase shows a looser structure than typical throughout the entire soil profile, which consists of an upper layer of poorly developed pale-red or faintly reddish brown crust, one-fourth inch in thickness, overlying loose, medium-textured sand of the same color to a depth of 20 inches. The subsoil, extending from 20 inches to 72 inches, is a pale reddish brown, loose, porous sand containing a small quantity of coarse sand and fine gravel. A small quantity of gravel is commonly present on the surface, and in places some is encountered throughout the profile. This variation is everywhere calcareous, but the greater part of it does not show the pronounced accumulations of lime appearing in the typical soil.

The Superstition sand is the most extensive type of soil in the Palo Verde area. With the exception of a strip of Dunesand, it occupies practically all the desert between the Mecca-Los Angeles Highway and the Niland-Rannells Road and a large part of the section east of Ironwood Mountain, or between the Mecca-Los Angeles Highway and the north boundary of the area. In addition areas are found skirting the mesa bluff southwest of Rannells. The large area west of Blythe is practically unbroken by drainage ways or other soil types, but the section east of Ironwood Mountain occurs in long, narrow areas traversed by shallow, intermittent drainage ways and separated from one another by narrow strips of Tijeras soils, Carrizo sand, or Riverwash. In all cases surface drainage is sufficiently developed, although on the greater part of the type underlain by porous sand the underdrainage is excessive.

The Superstition sand occurs on two distinct benches in the mesa, separated by a gentle rise of approximately 50 feet. The first bench, which lies 80 feet above the surface of the valley, is small, containing 2,300 acres. Of the second bench, about 13,000 acres have an elevation 130 feet above the valley and about 4,000 acres additional lie within the 140-foot contour above the ditches of the valley. These areas are confined to that part of the mesa south of McCoy Wash. North of this wash there is a considerable acreage 150 feet or more above the valley, while near the foot of the mountains the elevation is still higher. Except the western part of the strip lying between Ironwood and Mule Mountains, which drains westward into the Chuckawalla Valley, the entire type drains eastward to the Palo Verde Valley. Throughout the greater part of the type the slope is very gentle and uniform, large areas having the appearance of being nearly level.

None of this type of soil is under cultivation, as water is not available for irrigation and the land can not be successfully dry farmed. Practically all of it, however, is in private ownership, and a number of small tracts have been cleared and cultivated sufficiently to conform to the rules of homesteading. The native vegetation consists

of a rather vigorous growth of creosote bush, locally known as "greasewood," hop sage (*Grayia spinosa*), and other desert shrubs, scattering tufts of bunch grass, and a profusion of flowering plants, and such growths as tassojia, cholla, and other plants inhabiting arid regions. None of these are large enough to entail much expense for clearing the land, and the surface is smooth enough to be prepared for irrigation cheaply.

Under irrigation the Superstition sand would be easily cultivated and should be well adapted to the production of alfalfa, early truck, grapes, apricots, and other crops. However, the greater part of it lies at such elevations above the source of water that the installation of pumping plants and pipe lines and their subsequent operation would be very expensive, and under the present conditions, probably prohibitive. The first bench, containing about 2,300 acres and lying 80 feet above the valley, offers the most promise for reclamation, but here, as elsewhere over most of the type, the soil is loose and porous to a depth of more than 6 feet and would require a large quantity of water for irrigation. Moreover, this unit is small, which would make the acreage cost of installing irrigation works proportionately higher than on more extensive tracts. At the present time, the land is practically free from alkali, and in case it is ever irrigated, little danger of alkali accumulation need be feared.

The following table gives the results of mechanical analyses of the surface soil, subsurface, and subsoil of this type:

Mechanical analyses of Superstition sand

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
575818	Surface soil, 0 to 3 inches	3.9	11.5	15.7	36.7	20.7	3.9	7.0
575819	Subsurface, 3 to 28 inches	3.9	13.2	21.0	38.5	18.2	1.7	3.2
575820	Subsoil, 28 to 60 inches	3.7	26.6	22.3	27.4	9.8	3.1	6.7
575821	Subsoil, 60 to 72 inches	2.2	11.8	33.3	38.0	7.6	2.4	4.1

CARRIZO SAND

The Carrizo sand consists of light brownish gray or light grayish brown, loose, medium to coarse sand overlying light brownish gray sand of variable texture, containing a quantity of fine, waterworn gravel and extending to a depth of 6 feet or more. As a rule the content of gravel increases with depth, but the surface is comparatively free from gravel or stones, in which respect the type differs from Riverwash into which it merges with no definite line of separation. The material throughout the profile is porous and leachy, mildly calcareous, and free from alkali.

Included with the Carrizo sand, which is typically developed in the narrow desert washes, are some areas occurring in strips between these channels and the bluffs and also wind-modified fan-shaped areas around the mouths of drainage ways at the base of the mesa bluff. In the latter positions the soil is somewhat browner in color, finer in texture, and bears a close resemblance to Rositas fine sand.

This is one of the least extensive soil types in the area surveyed. It is confined mainly to narrow strips at the foot of the mesa west

and northwest of Blythe, and to McCoy Wash and other desert waterways entering the northwestern part of the valley. Except for a few hours following the torrential rains that fall on the desert at irregular and infrequent intervals the channels are dry, but with every flood the soil is changed, fresh coarse material being deposited on the surface, or that already in place being swept away. Near the edge of the mesa the type lies 75 to 100 feet below the desert, but within a few miles it climbs to practically the level of the adjacent lands. In the latter locations the fall is so slight that no permanent channels have been developed, and the surface is cut by a number of shallow drainage ways.

None of the Carrizo sand is under cultivation and the greater part of it has only a low potential value. Most of it is so open and porous that excessive quantities of water would be required for irrigation, while the cost of protecting the land from overflow would be greater than the returns would justify. A small acreage north of Fertilla and elsewhere under the mesa bluff, where the soil approaches in character the Rositas fine sand, is suitable for development and should be fairly well adapted to the production of alfalfa, grapes, and early vegetables.

The following table gives the results of mechanical analyses of the soil and subsoil of the Carrizo sand:

Mechanical analyses of Carrizo sand

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
575847	Soil, 0 to 12 inches	5.7	24.4	27.0	35.7	4.6	0.6	1.0
575848	Subsoil, 12 to 48 inches	8.1	17.6	31.7	34.4	4.9	1.3	2.2

IMPERIAL VERY FINE SANDY LOAM

The surface soil of the Imperial very fine sandy loam consists of 5 to 8 inches of light chocolate brown mellow very fine sandy loam, which is frequently quite smooth or silty. In the virgin condition the surface is firm, and uncultivated areas have a grayish appearance, though showing a chocolate or purplish tint when moistened or stirred. This is underlain by a layer of light chocolate brown, friable, fine or very fine sandy loam extending to 10 or 15 inches. Below this appears a layer of light chocolate brown, moderately compact silty loam or silt loam mottled with brownish-colored stains, extending to an average depth of 50 inches, where it rests abruptly on chocolate-colored or purplish-brown compact clay. The entire soil profile is calcareous, the lower subsoil somewhat more so than the surface layers, and practically all the type contains more than 0.2 per cent of alkali. The surface soil, however, is usually quite free, most of the salts being confined to the heavy clay layer in the subsoil.

The typical Imperial very fine sandy loam is a soil of small extent, and confined principally to small areas in the north end of the valley. The most prominent areas lie north and northwest of Blythe and in the vicinity of Fertilla. A few narrow strips occur east and north of Ripley.

This type of soil has a level to gently sloping surface and is easily prepared for irrigation. The type has good surface drainage, except in a few low areas near the levee east of Ripley and between this town and Blythe.

Although of small extent, the Imperial very fine sandy loam has some agricultural importance, as nearly all of it in the vicinity of Blythe and Fertilla is farmed. Probably 80 per cent of the entire type has been cleared of mesquite trees and is now under cultivation. Cotton is the principal crop, occupying about three-fourths of the cultivated acreage. Other crops are alfalfa, barley, wheat, milo, and a small newly planted acreage of grapes. Barley and wheat are sown generally with alfalfa and harvested green for hay. Cotton yields one-half to as much as 1½ bales, with an average of about 1 bale per acre. Alfalfa, under good treatment, yields about 7 tons per acre, and milo about three-fourths ton per acre.

This type of soil is held at $125 to $200 an acre, depending on improvements.

The Imperial very fine sandy loam is a desirable soil type as it is productive and easily worked. In addition to being adapted to the staple crops of the valley, it should be well suited to the production of lettuce, cantaloupes, and other early truck crops. The plowing under of alfalfa has proved decidedly beneficial, not only in increasing the yield of the following crop, but also in making the soil more firm and reducing drifting by winds.

Imperial very fine sandy loam, stratified phase.—The Imperial very fine sandy loam, stratified phase, is similar to the typical Imperial very fine sandy loam in surface characteristics, but is distinguished from it by having one or more light-textured pervious strata in the subsoil. The material in these pervious strata consists of light-brown or slightly pinkish colored, loose fine sand or fine sandy loam. The layers range in thickness from several inches to 2 feet. Usually there is only one layer of sandy material about 12 inches thick, but there may be three or four distinct layers between the deposits of clay. The stratified phase represents an intermediate condition between the Imperial and the Holtville soils, and in places resembles the latter as much as it does the former.

The Imperial very fine sandy loam, stratified phase, although of small extent, occupies a somewhat larger acreage than does the typical soil. It occurs in a number of small areas in all parts of the valley. The areas are most numerous east of Blythe, and not far from the levee south of Ripley.

It has the same character of surface as the typical soil, but the pervious underlying strata afford more thorough underdrainage through lateral movement of water. This is especially beneficial where deep drains are available, otherwise the sandy strata are waterlogged with each copious irrigation, and remain so until the water has been reduced by evaporation from the surface. Under these conditions there is grave danger of harmful quantities of alkali accumulating in the surface soil. In some localities this has already taken place, but the greater part of the surface soil of this phase does not contain injurious quantities of salts.

The Imperial very fine sandy loam, stratified phase, is not of great importance. Cultivation is confined largely to the central

and northern parts of the valley, probably 30 per cent of the total area being developed. The same crops are grown, and about the same yields are obtained as on the typical soil. It is handled in the same manner, except in certain localities less water is required for irrigation. Undeveloped tracts in the southern part of the valley are valued at $40 to $75 an acre; improved farms nearer towns are held at $125 to $200 an acre.

This phase is popular because of its productiveness and easy working qualities. It is adapted to the same range of crops as the typical Imperial very fine sandy loam type.

IMPERIAL SILTY CLAY LOAM

The surface soil of the Imperial silty clay loam, to an average depth of 12 inches, consists of a chocolate-brown friable silty clay loam containing a relatively large proportion of silt and clay. The subsoil is a chocolate-brown, compact silty clay to an average depth of 56 inches, where it is tinged with faint traces of red or pink. The material throughout is calcareous, although no visible accumulations of lime appear. Variable though moderate quantities of alkali are present from the surface downward.

The typical Imperial silty clay loam is of small extent. Most of it is confined to an irregular area, containing about 1 square mile, lying around Fertilla. Not all this area is typical, a strip along the west side adjoining Holtville silty clay being somewhat heavier in texture. This strip is more nearly the Imperial silty clay, and it was included with the silty clay loam type, because its area was not great enough to warrant separate mapping.

The surface of this type of soil is smooth, with a favorable slope for irrigation. Surface drainage is fair, but underdrainage is restricted by the impervious character of the underlying clay.

Although of small extent, this type of soil is of local importance, as it occurs within the oldest and best developed parts of the valley. Practically all of it is cleared and under irrigation. The principal crops are cotton, alfalfa, milo, barley, wheat, and lettuce. Cotton yields three-fourths to 1½ bales per acre, with an average of about 1 bale; alfalfa 5 to 7 tons, with an average of 6 tons per acre, and milo one-half to 1 ton, with an average of three-fourths ton per acre. Up to the year of the survey most of the barley and wheat had been grown for hay or pasture, but during that year (1922) a small acreage was harvested for grain. In the same year lettuce was grown commercially in the valley for the first time on the heavy-textured area of this type near Fertilla. The seed was planted the latter part of January and harvesting began the second week in May.

Well-developed land of this type of soil is valued at $150 to $250 an acre.

The Imperial silty clay loam is productive and adapted to the same range of crops as the Holtville and Imperial clays. Owing to its larger content of silt, however, the surface is much more mellow and much of it has the easy-working qualities of soils of lighter texture. Although somewhat better adapted to alfalfa than the Imperial clay, it is not so well suited to this crop as are the lighter textured types with pervious subsoils.

FIG. 1.—STONY SURFACE AND CHARACTERISTIC TOPOGRAPHY AND VEGETATION OF THE TIJERAS STONY SANDY LOAM

FIG. 2.—AREA OF RECENTLY DEPOSITED GILA VERY FINE SAND, SHOWING PROJECTING FENCE POSTS

About 5 feet of this soil material was deposited in this locality from overflow waters of the Colorado River during flood of May and June, 1922. Note growth of "arrowweed" which covered the flooded area between recession of the flood waters and November of that year

FIG. 1.—PROFILE OF THE SUPERSTITION SAND SHOWING COMPACTED UPPER LAYERS AND LOOSE DEEPER SUBSOIL

FIG. 2.—TYPICAL HEAVY GROWTH OF VEGETATION ON HOLTVILLE CLAY EAST OF RIPLEY

Imperial silty clay loam, stratified phase.—The surface soil of the stratified phase of the Imperial silty clay loam is identical in all respects with that of the typical Imperial silty clay loam, but the heavy subsoil is interrupted by one or more strata of fine sandy loam or fine sand. These vary in thickness and order of occurrence, but in most places the upper one does not appear within 2 feet of the surface and rarely are there more than two such layers within the 6-foot profile. As mapped this phase includes small bodies in which the surface soil contains a larger than normal quantity of silt and very fine sand, and in some localities, as near the southeast corner of the town of Blythe, the surface soil has the texture of a rather coarse silt loam.

The stratified phase of the Imperial silty clay loam occurs in small areas throughout the valley, with a total area several times that of the typical soil. A common position of this soil is along the principal drainage courses. In such positions the water table is high, the sandy strata ordinarily being saturated, and more or less alkali is present in the surface soil. In general the heavy-textured strata contain moderate quantities of alkali, but the sandy materials are almost invariably free. While surface drainage is fair, the underdrainage is good only in those few localities where outlet drains are sufficiently low to carry off the free ground water in the sandy layers of the subsoil.

This soil phase is of importance only in the northern and central parts of the valley, as most of it east and south of Ripley is still uncleared of the heavy growth of mesquite. About 35 per cent of it is cleared and under irrigation. The same crops are grown, with about the same degree of success, as on the typical soil. Owing to the fact that the water table normally stands in one of the sandy strata, the rise of alkali by capillarity has been facilitated, and many of the lower areas have strong concentrations of alkali at or near the surface. However, with the installation of deep drainage outlets this phase should be more readily reclaimed than the typical Imperial silty clay loam, as the sandy strata have the effect of tile in promoting the lateral movement of water. This phase is easily cultivated and is well adapted to the common crops of the valley.

The following table gives the results of mechanical analyses of the soil and subsoil of the Imperial silty clay loam:

Mechanical analyses of Imperial silty clay loam

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
575826	Soil, 0 to 12 inches	0.0	0.1	0.4	1.6	7.3	58.3	32.4
575827	Subsoil, 12 to 56 inches	.0	.0	.2	2.6	4.3	55.3	36.8
575828	Subsoil, 56 to 72 inches	.1	.1	.1	1.1	2.7	55.1	39.6

IMPERIAL CLAY

In the virgin condition the surface soil of the Imperial clay consists of 2 to 5 inches of chocolate-brown or purplish-brown clay.

This is underlain by chocolate-brown, or purplish-brown, compact clay which either extends without change to a depth of 6 feet or more or is interrupted by strata consisting of light chocolate brown or purplish-buff friable silty clay or clay loam. These strata are rarely more than 4 to 6 inches thick and may occur at any depth in the soil profile. Although friable and powdery when dry, the material is rather impervious and when thoroughly moistened becomes plastic and sticky. The entire profile is moderately to strongly calcareous, with accumulations of minute lime particles observable in places at 2 to 3 feet in depth. The soil, however, is too young to show any cementation, although the dense clay of the subsoil is quite impervious and locally is sometimes called hardpan. Alkali in considerable quantities is generally present to a depth of 6 feet and in places it has noticeably affected the structure of the soil. As a rule it is rather evenly distributed, but where high concentrations are found on the surface, a puffy condition exists, the first few inches being mellow and loose.

Only a few small areas of the Imperial clay are mapped in the Palo Verde Valley. These occur mainly as narrow strips bordering sloughs along the west side of the valley near the mesa bluff. Excepting two very narrow strips south of Ripley and two south of Palo Verde, the type is confined to small areas near Neighbours, west and northwest of Blythe, and west of Fertilla.

This type of soil occupies depressions with a flat surface. It receives the drainage from adjoining types, and both surface and subsoil are poorly drained, the latter owing to the dense, impervious character of the material.

At the present time the Imperial clay has little agricultural importance, as only about 1 per cent of it is farmed. A somewhat larger acreage has been used, but patches have been thrown out because of poor drainage and the surface accumulation of alkali. Most of the type is still covered with mesquite trees, cat's-claw, and smaller shrubs, with tules and marsh grasses bordering the sloughs. Owing to its small extent, land of this type is sold with adjoining soils.

Imperial clay, stratified phase.—The stratified phase differs from the typical Imperial clay in having strata of pervious material in the subsoil. The surface soils are identical. The pervious material consists of light-brown, grayish-brown, or slightly pinkish colored, loose fine sand, with occasional thin layers of fine sandy loam. As a rule there are not more than two light-textured strata within the 6-foot profile, more commonly only one. They vary from a few inches to 2 feet in thickness and have no uniformity of occurrence, though appearing ordinarily between 2 and 5 feet below the surface. Where two or more strata occur in the subsoil, or where the sandy material is extraordinarily thick, the phase has a close resemblance to Holtville clay.

The stratified phase occurs in the same low positions and is of about the same extent as the typical Imperial clay, there being only about a dozen areas in all ranging in size from 20 to 100 acres. These commonly are associated with the typical soil. They are most numerous west of Blythe. A number of areas occur south of Ripley.

Owing to the low, flat topography—the phase ordinarily lies only a little above the level of adjacent sloughs—the surface drainage is poor. The underdrainage also is inadequate, as the dense clays are impervious, and the sandy material, if lying 3 feet or more below the surface, is almost invariably saturated. With the digging of deep ditches to serve as drainage outlets, the sandy strata should have value in promoting the lateral movement of water. In most places the heavier layers of clay carry much alkali; the sandy material is comparatively free from injurious soluble salts.

This phase has a slightly greater importance than the typical soil, although not more than 10 per cent of it is under cultivation. The same crops are grown, with about the same results, as on the Holtville clay. The range in selling price is also about the same, though some of the low areas are cheaper, owing to poorer drainage and a larger content of alkali. It is better adapted to the staple crops of the valley, such as cotton, milo, and barley, than to crops whose profitable culture depends upon early maturity.

The following table gives the results of mechanical analyses of the surface soil, subsurface, and subsoil of the Imperial clay:

Mechanical analyses of Imperial clay

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
575829	Surface soil, 0 to 5 inches	0.1	0.1	0.1	2.1	14.2	40.4	42.5
575830	Subsurface, 5 to 20 inches	.1	.1	4.6	4.0	17.5	37.4	37.0
575831	Subsoil, 20 to 26 inches	.0	.0	.1	.8	38.8	36.1	24.4
575832	Subsoil, 26 to 72 inches	.0	.6	.3	2.0	13.7	34.4	48.2

HOLTVILLE SILT LOAM

The surface soil of the Holtville silt loam consists of 4 to 6 inches of light chocolate brown mellow silt loam of relatively light texture overlying slightly compact, smooth silt loam of the same general color faintly mottled with yellowish brown. At an average depth of about 12 inches this material grades into light chocolate brown friable silt loam, which rests abruptly at 24 to 36 inches on light-brown or light grayish brown porous fine sand.

The Holtville silt loam is one of the less extensive soils of the Palo Verde Valley, being confined to some 10 or 12 areas ranging in size from 40 acres to 160 acres. The most important areas are three-fourths mile east of Rocky Comfort School, 1 to 2 miles southwest of Blythe, and in the vicinities of Rannells and Ripley. The surface is smooth and the drainage good, except in some of the areas in the south end of the valley, which are sometimes flooded and which have a water table 3 to 5 feet below the surface. Most of the type is free from injurious accumulations of alkali.

This type of soil has little agricultural importance, as cultivation is confined to the small areas in the north end of the valley and to one of the areas near Ripley, or to perhaps 50 per cent of the total area of the type. Cotton, alfalfa, and milo are the only crops grown, the yields comparing favorably with those obtained on the light-textured soils of the Rositas series.

The following table gives the results of mechanical analyses of the soil, subsurface, and subsoil of the Holtville silt loam:

Mechanical analyses of Holtville silt loam

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
575834	Soil, 0 to 6 inches	0.0	0.1	0.1	1.9	35.9	50.1	11.4
575835	Subsurface, 6 to 12 inches	.0	.0	.1	1.2	8.2	72.7	17.8
575836	Subsoil, 12 to 34 inches	.0	.0	.1	.4	37.9	49.9	11.9
575837	Subsoil, 34 to 72 inches	.0	.1	4.7	72.1	14.8	5.1	1.9

HOLTVILLE SILTY CLAY LOAM

The surface soil of the Holtville silty clay loam, where typically developed, consists of chocolate-brown, or purplish-brown silty clay loam of rather light texture, extending to a depth of about 20 inches. The soil is mellow and only moderately compact. No marked difference in structure exists to the stated depth, except where a large concentration of alkali has caused the formation of a thin surface crust. The subsoil consists of light pinkish brown, loose, porous fine sand or fine sandy loam extending to a depth of 6 feet or more. Variations in depth at which the light-textured material is encountered are wide. Commonly it lies immediately below the surface soil, but in some places it does not appear nearer the surface than 3 or 4 feet. Where such condition exists the intervening material is of the same color as the surface soil, but it may be either lighter or slightly heavier in texture.

The Holtville silty clay loam is developed in small areas in all parts of the Palo Verde Valley. The most important lie immediately west of Blythe and scattered throughout the section west of Ripley.

The surface is smooth, mostly unbroken by drainage courses, and has a favorable slope for irrigation, and where drainage outlets are available the drainage is adequate. In some places, especially in the western part of the valley where outlets are lacking, both irrigated and undeveloped tracts of this soil have a high water table and are strongly impregnated with alkali. The salts ordinarily are confined to the heavy-textured surface soil, the porous subsoil showing no excess. In several areas west of Ripley the surface foot of soil contains 3 per cent or more of alkali.

The Holtville silty clay loam is an important soil type, about 60 per cent of it being in cultivation. The areas farmed are confined principally to the vicinity of Blythe and the north end of the valley, most of the other areas being covered with mesquite, cat's-claw, and alkali-resistant weeds. Every crop commonly grown in the valley is produced on this soil type, the largest acreages being in cotton, alfalfa, milo, barley, and grain hay in the order named. Cotton yields three-fourths to 1½ bales, with an average of about 1 bale per acre; alfalfa 6 to 9 tons, milo one-half to three-fourths ton, and barley and wheat hay 1 to 2 tons. In addition to the above named crops, alfalfa seed is beginning to be grown on this soil type, and a small acreage of grapes is being planted. In growing

alfalfa seed, the second cutting is generally used, although some harvest two crops of seed in one season. When this is done, the first seed crop is harvested early in July and the second early in September. The yields average between 350 and 500 pounds per acre per cutting, although some report as much as 600 pounds per cutting. Frequently the fields are pastured during the winter by cattle shipped in from Arizona. Most of the milo is not threshed, but is fed in the head, or stalks and head are fed together.

This type of soil is handled in about the same manner as the heavier soils in the valley, except that somewhat less water is required for irrigation. In a few instances, sweet clover is sown in the fall and plowed under in the spring, but the practice is not common.

Well-developed land of this type of soil in the vicinity of Blythe is valued at $150 to $200 an acre, while undeveloped tracts more remote from shipping points, can be bought for $25 to $50 an acre.

The Holtville silty clay loam is a very desirable soil, wherever drainage and alkali conditions are not unfavorable. Valuable areas lie in the vicinity of Blythe, but a considerable proportion of the type south of Blythe and west of Ripley has strong concentrations of alkali near the surface and will not be suitable for crops until reclaimed. Fortunately, owing to the porous subsoil at shallow depths, reclamation should be comparatively inexpensive, providing deep drainage ditches are available for carrying off the water used in washing out the salts. Areas unaffected with alkali are well adapted to the production of all crops grown in the valley, including such crops as cantaloupes, lettuce, grapes, and apricots. The plowing under of alfalfa is recommended as a means of increasing its productiveness.

The following table gives the results of mechanical analyses of the soil and subsoil of the Holtville silty clay loam:

Mechanical analyses of Holtville silty clay loam

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
575838	Soil, 0 to 20 inches	0.0	0.0	0.1	1.2	18.5	53.5	27.1
575839	Subsoil, 20 to 72 inches	.0	.1	.4	45.9	36.1	11.2	5.3

HOLTVILLE SILTY CLAY

The Holtville silty clay consists of dark chocolate brown, moderately compact silty clay, 6 to 10 inches deep, overlying a lighter chocolate brown or faintly purplish colored, compact silty clay, clay loam, or clay. This material, which is sometimes slightly mottled, varies in most places between 20 to 30 inches in depth, but in places extends to depths of 4 or 5 feet, where it is underlain by light-brown, pale-red, or light pinkish brown, loose, fine sand. The surface soil sometimes contains a relatively large content of clay, and when wet is sticky and plastic and not easily distinguished from the Holtville clay. When dry, however, it is fairly mellow and more readily cultivated than the heavier type.

All parts of this soil profile are calcareous, although no cementation has taken place, and no accumulations of lime carbonate are visible. The heavy-textured materials generally contain more than 0.2 per cent of alkali, but the sandy subsoil is alkali free. Generally the sands are saturated with water at less than 6 feet below the surface and in many places free ground water is encountered at 3½ feet. Some of the most productive and highly developed tracts on this type of soil have a water table at 3½ feet, but the fact that good crops are being grown under these conditions should not be taken as indicating that this depth will be permanently favorable to crops. It is said that the water table is rising. A high water table is conducive to the rise of alkali to the surface, and the numerous small patches showing strong surface concentrations are almost invariably associated with shallow ground water.

The Holtville silty clay is a soil of moderate extent and is quite generally distributed through the valley. The greater part of it occurs in closely associated bodies extending north from a point about 2 miles south of Neighbours to the north end of the valley. Several narrow strips occur along drainage ways south of Ripley.

The surface is nearly flat to gently sloping, and easily prepared for irrigation. In the virgin condition shallow drainage ways crossed the type, and leveling has only partly obliterated these, resulting in favorable conditions for surface drainage over most of the type. Underdrainage is adequate only in those few localities where deep natural drainage ways are found or where deep ditches have been dug.

The Holtville silty clay is one of the most important soil types in the Palo Verde Valley. The greater part of it from Neighbours north is cleared and under irrigation, while most of it south of Ripley is still covered with the native growth of mesquite trees. About 80 per cent of the total area of the type is under cultivation. The principal crops are cotton, alfalfa, milo, barley, and wheat. A small acreage of lettuce is being grown on this type of soil this year (1922) for the first time. Cantaloupes are also being introduced commercially, and there is a considerable acreage being planted in grapes. Cotton is the principal cash crop, occupying an acreage about equal to that of the other crops combined. Alfalfa is next in importance, and its acreage is being rapidly extended.

Cotton yields one-half to 1½ bales per acre, depending on alkali conditions and the efficiency of cultivation and irrigation. Alfalfa yields 5 to 8 tons, with an average of about 6 tons per acre, and milo one-half to 1 ton, with an average of about three-fourths ton per acre. Up to the present time most of the barley and wheat have been cut green for hay, machines not being available in the valley for threshing the grain. However, some of the better fields that have been threshed have yielded as much as 20 sacks of 140 pounds each of wheat per acre. Grain hay returns from three-fourths to 2 tons, with an average of about 1¼ tons per acre. The grains are frequently sown with alfalfa and pastured during the winter months. Alfalfa alone is sometimes pastured also one to three times during the winter with cattle shipped in from the ranges of Arizona. This industry has but recently been established in a small way, and there are many things that would seem to favor enlarging it.

The Holtville silty clay is one of the best farmed soils in the valley, although there are a number of fields that have been devoted to cotton for several years in succession. Some practice a rotation of cotton, barley or wheat hay, and milo. The barley or wheat is sown in November or December and cutting begins about April 10. When grown for grain the crops are harvested the latter part of May. The land is then plowed for milo which reaches maturity during early fall. When cotton follows itself the completion of picking is often delayed until well into the winter months. A beginning has been made in the production of alfalfa seed on this type of soil. The first cutting is used for hay and the seed crops are taken from the second and third cuttings. Melilotus or sweet clover is sown by some in September as a winter cover crop and plowed under in the spring. Dairying is conducted in a small way, milk being sold within the valley.

Land of this type of soil under irrigation is valued at $150 to $200 an acre, while undeveloped tracts in the southern part of the valley can be bought for $25 to $40 an acre.

A large proportion of the Holtville silty clay is favorably located with respect to roads and towns. It is naturally productive, responds readily to good treatment, and is well suited to the staple crops of the valley. It is somewhat more easily cultivated than the Holtville or Imperial clay, and is a little better adapted to alfalfa than these heavy types. Although a large proportion of it at the present time has the water table within 3½ to 5 feet of the surface, most of the type in the north half of the valley is comparatively free from alkali. In other sections, however, there are a number of areas having 0.6 per cent to more than 1 per cent of salts. As the sandy subsoils are nearly always alkali free, the entire salt content is confined to the overlying clays. The presence of these salts so near the surface, with a water-logged subsoil below, constitutes a condition calling for careful treatment in the matter of irrigation. Excessive use of water should be avoided and in general the land should be so managed as to prevent evaporation as much as possible. At the present time preparations have been made for installing a number of deep ditches to underdrain the valley. When these are completed it should be comparatively inexpensive to reclaim this land and maintain it in a high state of productiveness.

The following table gives the results of mechanical analyses of the soil and subsoil of the Holtville silty clay:

Mechanical analyses of Holtville silty clay

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
575840	Soil, 0 to 6 inches	0.0	0.4	0.3	1.9	8.8	50.0	38.9
575841	Subsoil, 6 to 38 inches	.1	.1	.2	7.0	12.3	39.0	40.4
575842	Subsoil, 38 to 72 inches	.0	.0	.2	59.2	31.3	4.5	4.2

HOLTVILLE CLAY

The Holtville clay consists, in the virgin condition, of a surface layer, about 2 inches thick, of chocolate-brown or purplish-colored,

loose, deflocculated clay. This is underlain by a layer of compact, purplish, or chocolate-colored clay varying from 20 to 36 inches in depth where it passes gradually into a compact silty clay loam to clay material of similar basic color faintly mottled with yellowish brown. The mottled layer is rarely more than 8 inches thick, and is frequently only 2 or 3 inches thick. Both of these layers are more or less impervious and are very dense and hard when dry. Absorbing moisture slowly, they are capable of storing a large amount and with proper cultivation will retain it for extended periods. The mottled layer rests abruptly upon light-brown, grayish-brown, or slightly pinkish, loose, fine sand extending to a depth of 6 or more feet. Free ground water is often encountered at the beginning of the porous stratum and frequently rises by capillarity into the mottled layer above. All of the clay layers commonly contain some alkali and are strongly calcareous, the second layer especially showing in many places gray particles of lime or flakes of soluble salts. The lime, however, is not sufficient to cause cementation or to produce definitely marked layers of concentration, while the alkali is rarely sufficient to prevent crop growth. Normally the sandy subsoil is only mildly calcareous and is free from alkali.

As occurring in the Palo Verde Valley, the Holtville clay is comparatively young, and characteristics of profile are not as markedly developed as in soils of advanced age. In the southern part of the valley much of this type has been flooded annually during the last few years with backwater from the Colorado River and after each recession of the floods a fresh deposit of pinkish or purplish-red clay has been left upon the surface. These deposits range from a thin veneer to as much as 6 inches in thickness during a single season. On drying, these newer deposits form into blocks surrounded by cracks through which the moisture from the underlying material is rapidly evaporated. The process of drying causes a rapid transformation in the character of this soil, the clay assuming a shalelike hardness and a structure resembling that of old valley filling material—the change taking place within a few months. These new deposits are comparatively free from soluble salts and contain somewhat less lime than the soil below.

In the vicinity of Palo Verde the depth of the clay is shallow and uneven, the heavy deposits being laid down during the last few years over Rositas fine sand having a dunelike topography. In places the crests of the dunes protrude above the clay, but being only a few rods across, they could not be shown separately on the map. Throughout the southern part of the valley the average depth to the underlying sand is about 2 feet, while in the northern part it is frequently 3 to 4 feet.

The Holtville clay is one of the most extensive soils in the Palo Verde Valley. The largest body, beginning northeast of Ripley, extends 12 miles southwest along the Laguna Palo Verde and for about 3 miles along the levee south of Ripley. Other areas lie near the levee northeast of Ripley, at Neighbours, and at various points near the bluff west and northwest of Blythe. In addition, a number of narrow strips border the sloughs throughout the valley part of the area.

In general, the Holtville clay has a comparatively level surface, although it is cut by a number of sloughs and drainage ways. A

large part of the type in the southern part of the valley is flooded annually by backwater from the Colorado River, but each year additional areas are being protected by the extension of a levee. The fall in the larger areas is usually sufficient to provide fair surface drainage, but in a number of small, low basins the run-off is slow. The water table is high under much of the type.

The Holtville clay is an important soil type. Approximately 12 per cent of it is cleared and under cultivation, but there are large areas in the southern part of the area that have not been developed. Most of the unused land is covered with a rather dense growth of mesquite and other small trees, cat's-claw, and a variety of thorny shrubs. (Pl. XVIII, fig. 2.) At the time of the survey there were several hundred acres in process of being cleared.

About the only crops grown on this type of soil are cotton, milo, barley, and alfalfa, the first named occupying the largest acreage. The yield of cotton varies considerably with the treatment given the land, especially with respect to irrigation. In places the yield is one-half bale or less per acre, while on well-prepared and properly irrigated fields it ranges between 1 and 1½ bales per acre. The average is reported to be about three-fourths bale per acre. Milo yields one-half to 1¼ tons, with an average of about three-fourths ton per acre, and alfalfa 5 to 7 tons, with an average of 6 tons per acre. Practically all the barley is grown in connection with alfalfa seeding and is cut green for hay. Both barley and alfalfa are sometimes pastured during the winter.

In preparing this soil for cotton the fields are usually plowed dry 6 to 8 inches deep some time in March, after which they are flooded. As soon as the soil is dry enough to work the field is disked into a mellow condition and then marked off into furrows and ridges, using a lister. Before planting, the latter part of April, water is run down the furrows until the ridges are moistened, and as soon thereafter as possible the surface is smoothed off with a harrow and the seed drilled in along the tops of the ridges. In preparing this soil for grain the fields are frequently plowed dry, disked, harrowed, and seeded before being irrigated.

Improved land of this type of soil, including water stock, is held at $140 to $175 an acre, while undeveloped tracts in the southern part of the valley are on the market at $60 to $125 an acre.

The Holtville clay is a productive soil, but requires more thorough tillage than soils of lighter texture, and this is relatively expensive. As the soil absorbs moisture slowly, it is best to use a small head of water for a comparatively long time; otherwise the lower end of the field may be damaged by flooding before the water has penetrated other parts of the field sufficiently. As a rule the checks on this type of soil should be shorter and narrower than on light-textured soils. Many of the low yields obtained can be attributed to insufficient irrigation or to the drowning and scalding of patches in the lower parts of the fields. To prevent the latter, outlet drains across the lower end of fields will be found especially useful. In the vicinity of Ripley there are a number of patches containing 1 to 2 per cent of alkali. Practically all the salts are confined to the heavy layers of the profile, or within 1½ to 3 feet of the surface. In some of these areas fair crops of cotton and milo are being grown,

but the greater part of the affected areas is still undeveloped. In many places free ground water is encountered within 3 to 5 feet of the surface, and permanent improvement can not be expected until the water table has been lowered by artificial drainage. When this has been done and adequate outlets provided it should be possible to wash out a part of the salts in the clay. Following this the land should be carefully irrigated and either frequently cultivated or kept as much as possible in cover crops in order to reduce evaporation and prevent the rise of alkali to the surface. Where not too strongly affected with salts, the Holtville clay is well suited to the production of staple crops such as cotton, milo, and grain, but only fairly well adapted to alfalfa. The soil is late and hard to work, and therefore is not well suited to the production of lettuce, cantaloupes, grapes, or other crops in which early maturity is essential.

The following table gives the results of mechanical analyses of the surface mulch, soil, and subsoil of the Holtville clay.

Mechanical analyses of Holtville clay

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
575843	Surface mulch, 0 to 2 inches	0.0	0.1	0.5	3.1	9.3	39.1	47.5
575844	Soil, 2 to 34 inches	.0	.0	.1	2.3	7.3	27.8	62.7
575845	Subsoil, 34 to 38 inches	.0	.0	.4	1.9	2.7	42.8	53.1
575846	Subsoil, 38 to 72 inches	.1	.3	3.1	42.7	42.4	5.8	4.8

GILA VERY FINE SAND

The surface soil of the Gila very fine sand consists of light-brown to faintly pinkish brown loose, mellow very fine sand. The depth varies greatly. Near the margins of the type it varies from only a few inches to about 1 foot in depth, while near the center of the larger areas it frequently extends to 4 or 5 feet in depth without apparent change. Since this type of soil represents materials recently deposited over the surface of a number of different soils, the subsoil lacks uniformity. In most of the areas it consists of light-brown, chocolate-brown, or slightly purplish colored, compact clay identical in all respects with the surface soil of the Holtville and Imperial clays. Light-brown or chocolate-brown clay loam or silty clay, similar to these types in the above-named series, and light-brown, porous sandy material corresponding to the surface soils of Rositas and Meloland types are also frequently found at various depths. Both the soil and subsoil are mildly calcareous, low in organic matter, and as a rule, contain only small quantities of alkali.

The Gila very fine sand covers an area of less than 5,000 acres. It occurs mainly in one body one-fourth to 1 mile wide and about 10 miles long extending along the levee from a point east of Blythe to about 2 miles south of Ripley. Several areas are also included in the area of undifferentiated soils between the levee and the river.

This type of soil is composed of the coarser grade of materials deposited by the Colorado River during the overflow of 1922. (Pl. XVII, fig. 2.) As mapped, it includes small areas of rather silty ma-

terial and of very fine sandy loam. The surface in general is fairly level, except for erosions with nearly vertical banks 2 to 3 feet high, where the swift swirling eddies existed during the flood. In places these banks mark the limits of the type; in others they form the walls of narrow washes which were scoured out by the shifting currents during the high stages of the flood. In most cases leveling is comparatively inexpensive. The surface drainage is well developed. Owing to the fact that the surface of the areas occupied by this type has been raised in proportion to the depth of the deposits the water table is now somewhat deeper than before the flood occurred. The underdrainage therefore is good where the loose very fine sand is several feet in depth and also where the new deposits were laid down over soils with a porous structure. Where the soil overlies heavy types of the Holtville or the Imperial series the underdrainage is restricted. Where the covered Holtville soil was shallow a stratified profile has resulted, and the drainage of such areas will be comparatively easy when the water table of the valley shall have been lowered by the completion of the proposed drainage ditches.

Since these new deposits in themselves carried little alkali, the surface soil in most cases contains but little salts. In places, however, especially east of Ripley, the deposits were left over soils strong in alkali, and in these locations the subsoil is still strongly affected. It is believed, however, that the general conditions regarding alkali have been improved. This improvement may be permanent or but temporary, depending on the future handling of the soil.

The Gila very fine sand is an important soil type, although very little of it has been releveled since the overflow. Owing to its newness and the lack of organic matter it would be improved by the growing and plowing under of alfalfa or other leguminous crops. It is one of the easiest soils to cultivate in the Palo Verde Valley and should prove well suited to the production of any of the crops now grown. It should be especially well suited to the production of alfalfa and early truck crops.

GILA SILT LOAM

The surface soil of the Gila silt loam consists of 6 to 12 inches of light-brown to light grayish brown smooth, floury silt loam carrying very little material coarser than very fine sand. The soil is almost entirely devoid of organic matter, and the surface is firm and compact. The subsoil is usually stratified, the upper part being composed of compact, chocolate-colored silty clay loam or clay which passes at 2 to 3 feet in depth into light-brown, to light chocolate brown, porous fine sandy loam or fine sand. The soil when wet is slightly sticky, but under favorable moisture conditions it yields readily to cultivation.

The Gila silt loam is confined to a few strips one-fourth to one-half mile wide lying in the vicinity of Ripley. The surface soil is composed of finely divided material deposited in the valley by the flood of 1922. The surface is smooth and drainage is well developed. Both the soil and subsoil contain varying quantities of alkali, although the highest concentrations are confined within the heavy layers of the subsoil.

This soil type is of considerable importance in the valley, although at the present time not more than 10 per cent of it is under cultivation. About one-third of the area covered by this type was formerly cultivated and the work of releveling and rebuilding irrigation structures is expected to be well under way within a few months.

This soil should be well suited to the production of the staple crops. Its greatest need is organic matter, which can best be supplied by the growing and turning under of alfalfa.

MELOLAND VERY FINE SANDY LOAM

The Meloland very fine sandy loam consists typically of 6 to 10 inches of light chocolate brown mellow very fine sandy loam overlying material of the same color and of slightly finer texture extending to a depth of 36 to 48 inches where it passes abruptly into chocolate-brown or purplish compact clay loam or clay. As a rule, this is somewhat mottled with yellowish-brown, pale-red, or bluish-gray stains. This type of soil is subject to considerable variation, as in places it is the product of irrigation, heavy materials being deposited over areas of lighter textured fine sandy materials and later mixed by cultivation. In some places, also, the upper subsoil consists of silty clay loam and may appear within 20 inches of the surface.

The type includes as mapped a light-textured variation in which the surface soil consists of light-brown faintly tinged with red, incoherent, micaceous very fine sand, varying from 20 to 40 inches in depth.

Both the soil and subsoil are mildly calcareous, the subsoil containing slightly more lime than the surface. Normally the surface soil is free from alkali, but the heavy subsoil usually contains moderate to strong concentrations of soluble salts.

Little of the typical Meloland very fine sandy loam is mapped in the Palo Verde Valley. The largest area occurs 1½ miles northeast of Palo Verde. The lighter textured variation is confined to a few small areas in that part of the valley north of Blythe.

In the virgin condition, the surface is level or slightly uneven with scattered wind-blown hummocks from 2 to 3 feet in height. Leveling is comparatively inexpensive, and leaves the surface with a uniform slope favorable for irrigation. Surface drainage is usually adequate, although a part of the body lying opposite the mouth of McCoy Wash is sometimes flooded after heavy rains on the desert. The underdrainage is somewhat deficient, the compact subsoil retarding percolation.

Owing to its small extent the type is unimportant. Cotton and alfalfa are the principal crops. The area near Blythe has recently been set in grapes.

This type of soil has about the same range in value as the Rositas fine sand and is handled in practically the same manner. It is easily cultivated and should be well adapted to the production of grapes, early truck crops, and alfalfa, the last-named crop being especially desirable as it protects the loose surface of the lighter textured areas from blowing.

Meloland very fine sandy loam, stratified phase.—The surface soil of the stratified phase of the Meloland very fine sandy loam is identical with that of the typical soil and frequently no difference exists within the first 2 or 3 feet. The subsoil, however, contains one or more layers of pervious fine sand or fine sandy loam separated from each other by sharply defined layers of compact silty clay loam, clay loam, or clay. The pervious strata vary in thickness from a few inches to 2 or more feet. As a rule, the surface averages somewhat more shallow than in the typical soil, the compact clay loam or clay being reached within 12 to 20 inches in depth. These in many areas are marked with light-brown or rust-colored stains. The sandy layers are very distinctly separated from the layers of clay. Like the material included with the typical Meloland very fine sandy loam it includes a variation of loose very fine sand texture.

The stratified phase covers an area several times as large as the typical soil and occurs in the same localities north of Blythe. One small area lies about 2 miles west of Ripley and a number of areas west and southwest of Ripley. It has the same configuration with satisfactory fall, and surface drainage is good. Underdrainage also is somewhat better, where outlets have been provided, owing to the sandy layers, which facilitate the lateral movement of water. Up to the present time, however, few drainage outlets have been provided, and most of the natural drainage ways are too shallow to be of service in carrying away the surface water. Because of this, the lowest stratum of sandy material is generally saturated. Nevertheless, except in a few places where the water table is unusually high, the surface soil is practically free from alkali and only the heavy strata in the subsoil contain appreciable quantities.

Owing to its small extent, this phase is unimportant. About half of it is under irrigation and the rest is covered with mesquite, cat's-claw, and creosote bush. Cotton, alfalfa, and milo are the principal crops, the first named occupying the largest acreage. Grapes are grown to some extent. The yields average about the same as on the Rositas fine sand and the soil is handled in practically the same manner.

Unimproved land, without water stock, can be bought for $25 to $50 an acre, while improved land commands $150 to $200 an acre.

Both the typical Meloland very fine sandy loam and the stratified phase are well adapted to the staple crops of the valley. The soil is mellow and easily cultivated, and owing to its firmer surface it is less readily drifted by winds than the lighter soils of the valley. Like all of the other sandy types, it is low in organic matter and would be improved by the addition of barnyard manure or the plowing under of alfalfa.

ROSITAS FINE SAND

The Rositas fine sand consists of light-brown or yellowish-brown loose, micaceous, fine sand extending to a depth of 6 feet or more. The material throughout is open and porous, but the surface soil in its natural state, being almost entirely devoid of organic matter, is especially loose and incoherent and easily shifted by winds. Under irrigation the surface is becoming heavier, many of the older fields showing a thin deposit of silt and clay. The surface of these areas

has assumed the purplish or chocolate cast characteristic of deposits from the mud-laden waters of the Colorado River.

As mapped the type includes dunes with small intervening depressions of heavier material, the latter ranging from a few feet to several rods across. The heavier soil is usually composed of light-colored loam or clay loam resting on fine to very fine sand at depths of 1 to 2 feet. In some places, as near the foot of the bluff west of Rannells, the area of the small depressions is nearly equal to that of the dunes, but neither dunes nor depressions are sufficiently large to be indicated separately on the map. Typically both the soil and subsoil are mildly calcareous, but owing to the unstable character of the material no modification through weathering is apparent in any part of the profile.

Although of relatively small extent, the Rositas fine sand is widely distributed over the valley. Most of the areas range in size from 20 to 40 acres, although there are a number in the vicinity of Blythe, Rocky Comfort School, and in the sections 2 miles north and 2 miles west of Ripley that vary from 80 to 320 acres in extent. A number of strips ranging from one-eighth to one-fourth mile wide and several miles long border the valley under the mesa bluff and larger areas lie opposite the mouths of washes issuing from the desert.

The topography is characterized by wind-blown hummocks and dunes with intervening flats or depressions. The hummocks and dunes range from 2 to 20 feet in height, and nearly the entire type occupies a position a few feet higher than adjoining soils. The soil absorbs moisture readily, is well drained, and free from alkali.

The Rositas fine sand is relatively unimportant. Only about 5 per cent of it has been leveled for irrigation, the rest is fairly well covered with mesquite, creosote bush, and other shrubs, which protect it to some extent from drifting. (Pl. XIX, fig. 1.) So far only the smaller areas have been prepared for irrigation and these are confined principally to the northern part of the valley. Alfalfa and cotton are the principal crops, the former occupying somewhat the larger acreage. From some of the better fields eight and nine cuttings of alfalfa are reported to have been made, with average seasonal yields of 8 tons per acre. When cotton follows alfalfa the yield averages one bale or more per acre, but there are fields in the valley which are said to have been planted to cotton five to nine years in succession, and under this treatment the yields have fallen off in some cases to less than one-half bale per acre.

Well-improved land of this type of soil commands $150 to $200 an acre; unimproved tracts without water stock can be had for $25 to $50 an acre.

Owing to the uneven surface, the Rositas fine sand is an expensive soil type to prepare for irrigation. Once leveled, however, it is a popular soil because it is easily worked, fairly retentive of moisture, and is one of the earliest soils in the valley. It is well adapted to the production of alfalfa, lettuce, cantaloupes, tomatoes, and other truck crops in which early maturity is essential. Because of its earliness, it should be well suited to the production of early table grapes, apricots, and strawberries. The greatest need of this soil is organic matter, which can best be supplied by growing and plowing under alfalfa.

ROSITAS FINE SANDY LOAM

The surface soil of the Rositas fine sandy loam has considerable variation in texture and depth. In general, the type consists of 4 to 8 inches of chocolate-brown or purplish fine sandy loam overlying light-brown, grayish-brown, or slightly pinkish brown, loose, porous sand of fine to medium texture, extending to a depth of 6 feet or more. The surface soil is chiefly the result of clay and silty material being deposited during the last few years by irrigation water or by recurring floods. Since it is confined to small patches, usually at the lower ends of irrigated fields, the surface receives appreciable accretions with each irrigation. The type, therefore, includes small patches approaching a loam in texture, and other small bodies where the heavy material is very shallow. In general, the texture is becoming heavier with continued irrigation. The type is slightly calcareous and free from alkali.

Only a little of the Rositas fine sandy loam is mapped. It is confined mainly to small areas in the northern and central parts of the valley. Surface drainage is well developed, but the water table frequently stands within 5 feet of the surface.

Owing to its small extent, this type of soil has little agricultural importance. About three-fourths of it is in cultivation and the rest, most of which is in the southern part of the valley, is covered with mesquite, cat's-claw, and creosote bush. The same crops are grown and about the same yields are obtained as on the Rositas fine sand.

The Rositas fine sandy loam is especially adapted to the production of alfalfa, and early truck crops. The surface is firm and is not affected by winds as are the lighter soils of the valley.

The following table shows the results of mechanical analyses of the soil and subsoil of the Rositas fine sandy loam:

Mechanical analyses of Rositas fine sandy loam

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
575856	Soil, 0 to 5 inches	0.3	0.3	0.5	19.9	43.5	19.5	14.4
575857	Subsoil, 5 to 72 inches	.0	1.0	5.2	50.8	35.2	4.2	3.7

ROSITAS VERY FINE SANDY LOAM

The surface soil of the Rositas very fine sandy loam consists of light-brown or grayish-brown, highly micaceous very fine sandy loam with an average depth of 6 inches. Below this is a light-brown fine sandy material faintly mottled with yellowish brown. At depths ranging between 30 and 40 inches this material grades into light-brown or grayish-brown porous very fine sand or fine sand.

Some small areas of very fine sand have been included. As a rule the soil in these areas is a little lighter in color than the typical soil, although both usually show a tinge of red or pink. It is loose and easily drifted, although the surface averages a little firmer than that of the Rositas fine sand. The entire soil profile is mildly calcareous and is usually free from alkali.

The Rositas very fine sandy loam is developed mostly in narrow strips along the east side of the valley. A number of small areas occur in the vicinity of Blythe, along the levee both north and south of Ripley, and along the foot of the mesa west of Palo Verde and Rannells.

The topography ranges from nearly level to slightly hummocky, with dunes in places 2 to 3 feet in height. Drainage is adequate, except in the lower parts of the valley, where the water table stands within 5 feet of the surface.

This type of soil is important agriculturally only in the vicinity of Blythe, where the greater part of it is in cultivation. Probably 75 per cent of the type is uncleared. Near the river it supports a growth of willow, cottonwood, and arrow weed; elsewhere the growth is mesquite, creosote bush, and other small shrubs. The same crops are grown with about the same success as on the Rositas fine sand. These two soil types are handled in the same manner and have the same range in selling price.

The Rositas very fine sandy loam is one of the best soils in the valley for the production of alfalfa and early truck crops. The soil is easily cultivated and fairly retentive of moisture. Owing to the generally smooth surface, the land is more cheaply prepared for irrigation than is the Rositas fine sand and less trouble is experienced with drifting. The soil, however, is in need of organic matter and would be greatly benefited by applications of barnyard manure or the growing and plowing under of alfalfa.

The following table gives the result of mechanical analysis of the soil of the Rositas very fine sandy loam:

Mechanical analysis of Rositas very fine sandy loam

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
575858	Soil, 0 to 6 inches	*Per cent* 0.1	*Per cent* 0.0	*Per cent* 0.1	*Per cent* 2.1	*Per cent* 65.2	*Per cent* 27.3	*Per cent* 4.2

ALLUVIAL SOILS, UNDIFFERENTIATED

The Alluvial soils, undifferentiated, occupy the land lying between the levee and the Colorado River. This area is flooded with every period of high water. The soils consist mainly of the Holtville types, but within this strip there occur other types found in the Palo Verde Valley. These soils were not mapped in detail because of their inaccessibility. The areas are thickly timbered with cottonwood and willow (Pl. XIX, fig. 2) or covered with thickets of mesquite and arrow weed. The area of such soils is 16,384 acres, or 25.6 square miles.

Cultivation is attempted on only two fields in this unprotected belt. In these barley is sown in the fall and cut green in the spring for hay. If the winter is favorable and the floods do not arrive too early, good yields are obtained, but the crops can not always be harvested in time. Were it not for the floods, these soils would be as desirable as those in the rest of the valley. In their present condition, they are not suited to farming.

FIG. 1.—CHARACTERISTIC TOPOGRAPHY AND VEGETATION ON THE ROSITAS FINE SAND

The taller growth in the background is mesquite

PHOTO BY UNIV OF CALIF.

FIG. 2.—VIEW NEAR EHRENBERG FERRY ON THE COLORADO RIVER, SHOWING HEAVY GROWTH OF WILLOW AND COTTONWOOD ON AREA OF UNDIFFERENTIATED ALLUVIAL SOILS

RIVERWASH

Riverwash consists of a variety of materials occupying the channels of intermittent streams issuing from the mountains and extending valleyward across the desert parts of the area. The soil in these positions is a gray, coarse sand containing gravel and cobbles ranging from a few inches to 1 foot or more in diameter. The coarsest material is near the mountains, while near the edge of the mesa the soil is frequently loose, porous, clean, gravelly, coarse sand in which fine material is almost entirely lacking. This is a nonagricultural type.

DUNESAND

Dunesand consists typically of light-brown or grayish-brown, loose, incoherent fine sand extending to a depth of several feet without material change. This type resembles Rositas fine sand, but differs from it in being more barren of vegetation, looser in structure, and more easily drifted.

Only one area is mapped in the area surveyed. This lies on the mesa west of Blythe. Owing to its tendency to drift and position above the source of water supply Dunesand is unfit for agricultural use.

ROUGH BROKEN LAND

Rough broken land consists of areas whose surface is too steep or broken for agriculture. It includes the steep escarpment, 50 to 100 feet in height, separating the alluvial valley from the mesa, and extensive foothill areas between the mesa and the mountains. In all the larger bodies the surface is strewn with angular fragments of basalt, granite, or schist, and in a number of areas west of Palo Verde highly polished waterworn gravel is abundant. As mapped, the Rough broken land includes undifferentiated areas of stony and gravelly types of all of the desert series. The surface is too rough and broken for tillage but is not mountainous like Rough stony land. It is entirely valueless for agriculture.

ROUGH STONY LAND

Rough stony land consists principally of rugged, barren mountains which are extremely steep and stony. A large part of the type consists of rock outcrop or very shallow soil containing bowlders and angular fragments of varying size derived from the country rock. Areas mapped as this type have no value for agriculture.

IRRIGATION

Irrigation began in the Palo Verde Valley in the late seventies, when a small acreage in the north end of the valley was watered and used principally for stock-raising purposes. The water was obtained by gravity from the Colorado River, the point of diversion then used being the same as is used to-day. After the first attempt nearly a quarter of a century elapsed before further development began, and then for several years progress was slow. In fact, active irrigation

development dates from about 1908, when the Palo Verde Mutual Water Co. was organized and there began the construction of a comprehensive system of canals. In 1909, 30,000 shares of water stock, representing an equal number of acres, was in the hands of private owners, although up to the present time not more than this acreage is actually being watered. During the early years alfalfa, milo, and small grains for hay were the principal crops, with potatoes, sweet potatoes, and vegetables grown for home use. In 1911 cotton was introduced and has reached such importance that during the last few years it has occupied one-half to three-fourths the entire irrigated acreage.

All the water used for irrigation in the Palo Verde Valley is derived by gravity from the Colorado River. The supply is abundant, the river having a watershed of about 244,000 square miles and a mean annual run-off at Yuma, Ariz., of about 17,000,000 acre-feet.[2] The water is diverted through a cut in granite rock at the extreme north end of the valley, from which point it is carried through a system of main and lateral canals to all parts of the valley. The irrigated area begins within about 4 miles of the intake, and there is thus a comparatively short length of canal requiring maintenance work through unproductive lands.

The Colorado River carries large quantities of silt. From observations made at Yuma by the United States Reclamation Service, it was found that the annual load of silt carried past this point varied from 98,000,000 tons in 1910 to 278,000,000 tons in 1911.[2] Assuming the average load to be 160,000,000 tons, the silt carried by the river is equivalent to 80,000 acre-feet, or sufficient each year to cover 1 square mile to a depth of 125 feet. During the course of irrigation a quantity of silt passes through the heading and is deposited along the canals. Unless this is removed the ditches soon fill up and become useless. The removal of silt from the main and lateral canals entails an annual expense of many thousands of dollars, as dredges run by high-powered machinery must be kept in continual operation the year round.

The quantity of water used in irrigation varies considerably with the crop grown and the character of the soil. Where winter crops are grown in addition to summer crops the water demands are high; the rate of evaporation probably not far from 6 feet per year does not favor a high duty of water.[3] Less water is used on the light-textured soils than on the heavier types, but there is a tendency toward overirrigation on all soils of the valley. According to information furnished by officials of the Palo Verde Mutual Water Co., the average duty of water in the Palo Verde Valley is between 3 and 5 feet per acre. In a number of sections more than 5 acre-feet are said to have been used in the past. In its present condition the valley is an area of poor underdrainage, and over the greater part of it the water table has risen since irrigation began to within 5 to 7 feet of the surface, and in a number of localities it is only 2 to 3 feet below. Most crops are able to adjust themselves to a shallow feeding

[2] Water Supply Paper No. 395, United States Geological Survey.
[3] From measurements made by the California Development Co. in the Imperial Valley from 1904 to 1906, inclusive, it was found that the annual loss by evaporation from a water surface is 6.73 feet.

zone, if the ground water remains at a uniform depth throughout the year, but a high fluctuating water table, like that in the Palo Verde Valley, where the ground water rises with the fluctuations of the river, is especially injurious to deep-rooted plants such as alfalfa and fruit trees, since the deeper roots, if once developed, are likely to be destroyed. During the present season (1922) nearly 1,000 acres of grapes for table use have been planted within the Palo Verde Valley. The principal advantage of grape growing in this section is the favorable climatic conditions which should give early ripening, carrying with it the advantage of higher prices incident to early shipments. The condition of the soil as regards soil moisture, however, is of great importance during the ripening of grapes, as during this period it is generally conceded that moisture should be withheld. In the Palo Verde Valley the present conditions are not everywhere favorable for the early ripening of grapes, as the rising of the water table, following the rising of the river in May and June, tends to delay ripening.

In irrigating grapes, cotton, and truck crops the furrow system is used. In irrigating alfalfa and small grains the flooding system is used, the water being turned into long, narrow checks or "lands," which have been leveled and bordered by ridges. Most of these lands are about 100 feet wide and are one-fourth mile long. On heavy soils that are comparatively flat these dimensions have given satisfactory results, but where the slope is pronounced or on light-textured soils it is better to reduce both the width and length of the lands in order to avoid flooding at the lower ends. In general, heavy-textured soils require small heads applied for a comparatively long time, as with a large head the water passes over the surface too rapidly to permit of proper penetration.[4]

On the other hand, in irrigating sandy soils it is necessary to apply the water in such a way that it will reach the lower end of the field before the upper end is overirrigated. This can be accomplished by narrowing and shortening the lands and by using a large volume of water for a comparatively short time. Alfalfa is usually irrigated just before or just after the removal of the crop, and in some instances it is watered again in about 15 days, when the plants are 6 to 10 inches high. Apparently most of the soils in the Palo Verde Valley are overirrigated, especially under the prevailing conditions of inadequate underdrainage.

The irrigation system is owned and controlled by the farmers of the valley, who are organized under the name of the Palo Verde Mutual Water Co. Interest in the water is originally obtained through the purchase of water stock, each share being allotted to 1 acre of land. In addition an annual assessment is levied against each share for the maintenance of ditches and for other operating expenses, the amount varying somewhat from year to year.

ALKALI

The most common alkalis, or soluble mineral salts, in the soils of the Palo Verde area are sodium chloride (table salt), calcium

[4] Irrigation of Alfalfa in Imperial Valley, Bul. No. 284, Univ. of Calif. Agr. Expt. Sta., by Walter E. Packard.

chloride, sodium sulphate (Glauber's salts), sodium bicarbonate (baking soda), and magnesium sulphate (Epsom salts). These are all classed as "white" alkali.

Of the "white alkalis" the chlorides are generally considered the most harmful, the sulphates less harmful, and the bicarbonates in themselves appear to have but slightly injurious effects on plant growth, although under certain conditions they may be converted into sodium carbonate, or "black alkali," which is the most harmful of all. However, not only is black alkali not troublesome in the area at the present time, but its development is not likely to become serious in the future, as in soils well supplied with sodium sulphate, or gypsum, the reaction giving sodium carbonate rarely takes place.

In addition to the kind of alkali in soils, its distribution in the soil profile is important, as alkali to be harmful must be within reach of plant roots. A certain concentration near the surface may preclude plant growth, while the same concentration, if confined to the subsoil, may show but little or no effect on shallow-rooted crops. Distribution is effected through the movement of soil water in which the salts are in solution, and the rate and extent of this movement is dependent on the supply of water present, the character of the soil with respect to texture, structure, and conditions of underdrainage and the rate of evaporation from the surface. In heavy, compact soils the movement of water is slow, while in light-textured soils it is relatively rapid. If the soil water can be kept moving downward, the salts in solution are carried down with it and confined in the subsoils or, if the deep subsoil drainage is adequate, permanently removed through underground drainage. On the other hand, an upward movement of soil water brings the salts to the surface, where a high concentration may prove disastrous to crops. Light-textured soils, having a lower water-holding capacity than clays, are more quickly affected by a given percentage of alkali. Most of the lands in the valley affected by alkali are of medium to heavy texture, or have the strongest concentrations in heavy-textured strata in the subsoils.

In determining the alkali content of the soils borings were made to a depth of 6 feet, and the content of total salts of each foot determined with an electrolytic bridge especially designed for this purpose. The content of alkali is stated on the basis of the proportion of salts in the air-dried soil and is shown upon the accompanying map in the form of a fraction, the numerator, or number above the line, showing the percentage in the surface foot, and the denominator, or number below the line, showing the average percentage to a depth of 6 feet.

The map as constructed shows two conditions within the Palo Verde Valley, namely, alkali-free areas and areas containing alkali. The first grade includes those areas whose average total salt content is less than 0.2 per cent within the 6-foot section, and so distributed as to be noninjurious to crops. The second grade includes those areas whose total salt content ranges from 0.2 per cent to 3 per cent or more. The first grade is confined largely to light-textured soils in the northern part of the valley, or to shallow, recently deposited clays overlying light-textured subsoils in the southern part of the valley. It comprises about 80 per cent of the Palo Verde

Valley. Within these areas no appreciable damage is being caused by alkali, and under normal methods of irrigation serious alkali troubles are not likely to occur.

The second grade includes a wide range of conditions, as it includes slightly affected areas in which there is no indication of accumulation of alkali either upon the surface of the soil or in the character of crop growth, but in which the total content of salts exceeds 0.2 per cent; and also areas so strongly impregnated with salts that crops can not be successfully grown. The latter condition, however, in the Palo Verde Valley, is confined to small areas near canals or in which a shallow-water table has caused a high concentration of salts upon or near the surface. From the results of tests of soils throughout areas of this grade of alkali land it appears that the greater part of it ranges in alkali content between 0.4 per cent and 2 per cent. In some cases good crops are being grown on land containing as much as 1 per cent of alkali, and frequently excellent results are obtained in the Palo Verde Valley on soils containing 0.6 per cent of salts. Usually under these conditions the salts are localized largely in heavy-textured materials in the subsoil, the surface soils being comparatively free. Over the greater part of the land of this grade the crops are visibly affected by alkali.

A considerable proportion of such land is underlain by a high water table. As the saturated subsoils are comparatively free from alkali, the salts in these areas are most commonly found within the surface soils, or in heavy-textured strata in the subsoil.

While alkali is not confined to any class of soils, it is most commonly developed in the soils of heavy texture. In practically all cases in the Palo Verde Valley, a high salt concentration near the surface is the result of a high or rising water table. Under the present conditions of inadequate underdrainage, the water table is locally reported to have risen in certain parts of the valley from a depth of 16 feet in 1913 to a depth of 7 or 8 feet now. In other parts of the valley, such as the low strip along the west side under the mesa bluff, the present water table stands at only 1 foot to 20 inches below the surface. To correct this condition it is said funds are already provided to construct a number of deep drainage ditches across the valley. When a sufficient number of these have been installed, the reclamation of most of the alkali lands in the Palo Verde Valley should be a comparatively simple matter.

In the reclamation of alkali lands the most practical and satisfactory method so far devised is to wash out the salts by flooding and underdrainage. This removes the salts permanently from the feeding zone of plants. The facility with which this can be done depends upon a number of factors, among which are the water supply, the relative porosity of the soils and subsoil, the availability of drainage outlets and the character of the salts. Fortunately all of these factors are favorable in the Palo Verde Valley, except that of underdrainage, and, as already stated, provision has been made for supplying this. Water is available in abundance. The greater proportion of the valley is made up of soils of the Holtville and Rositas series, or types with pervious, sandy subsoils, which favor the downward movement of water. Practically all of the salts present are white alkali, or materials which are readily soluble, and therefore easily leached away.

Because of the many factors which influence plant growth in the presence of alkali, only the most general statements can be made concerning the maximum percentage of salts which various crops will endure. Among the crops which are least affected by alkali may be mentioned Rhodes grass, date palms, and rice. Rhodes grass has been introduced on strongly affected alkali lands in the Imperial Valley and is giving considerable success. The choice of crops to be grown on alkali land is influenced to some extent by the distribution of the salts in the soil. Thus alfalfa, milo, or other deep-rooted crops will frequently succeed where the salts are localized near the surface, when barley or wheat or shallow-rooted crops would be a failure. Cotton in its early stages of growth is easily affected by a surface concentration of alkali, but is fairly resistant in its later stages. Cantaloupes and lettuce are grown successfully on slightly affected lands, but the planting of grapes, apricots, and tree fruits on lands affected with alkali, or on lands in which a shallow water table varies with the seasons, should always be avoided.

DRAINAGE [5]

In the Palo Verde Valley, as is frequently the case in irrigated areas having an abundant supply of gravity water, there has developed, over certain portions of the valley, a water table so near the surface as to be of injury to crops.

Previously to the construction of the levee system the valley was subject to periodic overflow from the Colorado River. This has left a topography in which the land is higher along the river bank than at the foot of the mesa, this difference in elevation in some cases being as much as 11 feet at two points at right angles to the general course of the river. The average slope of the valley is very nearly the same from north to south as it is from east to west, being about 1½ feet per mile.

Overflow has resulted in the formation of a number of roughly parallel sloughways following the line of greatest fall. At the upper end of the valley these are rather shallow, being only 3 to 5 feet below the general surface, but at the lower end of the valley they have generally converged into one main slough known as the Laguna Palo Verde, a channel of considerable size and importance. The Laguna Palo Verde, which enters the Colorado a short distance south of Palo Verde, afforded a means by which flood waters returned to the river. There is no direct connection at present between the overflow channels at the upper end of the valley and the laguna. In many cases these channels have been reduced by cultivation to such an extent that they are not readily traceable, and as more of the valley becomes farmed the less important ones will be obliterated entirely.

Since much of the valley lies at an elevation below or on a level with the Colorado River, it is not surprising that the normal water table should be much closer to the surface than is usually the case in the desert regions of the Southwest. It is said by old residents that prior to irrigation in the valley water could be obtained during the dry season at depths ranging from 15 to 20 feet from the surface.

[5] By Walter W. Weir, drainage engineer, assistant professor of soil technology, University of California, Berkeley, Calif.

In 1913 well water was obtainable at a depth of 16 feet at the present site of Rannells. Since the introduction of irrigation there has been a material rise in the general ground water table, so that now water can be reached within 7 to 9 feet in practically any part of the valley and over a very considerable part is from 4 to 5 feet from the surface, while 2 feet is not uncommon in certain low areas. The water table has risen to about 7 feet from the surface at Rannells since 1913. This represents a rise of nearly a foot per year. This rise is no doubt approximately comparable to the rise over the valley and is due almost, if not entirely, to the application of irrigation water. In the early part of April, 1922, observations on the depth to water were made; a few of these, taken at random, indicate the prevalence of a high-water table.

Borings showed water at 2 feet one-half mile north of Rocky Comfort School; at 3 feet, 3 miles west and 2 miles south of Blythe, 1 mile east of Blythe, and 1 mile west of Neighbours; at 4 feet, 2½ miles west of Neighbours; at 4½ feet, 1½ miles west and one-half mile south of Fertilla, 1½ miles west and 2 miles south of Fertilla, 2 miles west and one-fourth mile north of Ripley, 2¼ miles east and 1½ miles north of Ripley, 3 miles south of Ripley, and 2¼ miles north of Palo Verde; at 5 feet, 3½ miles west and one-half mile north of Blythe; at 6 feet or more, one-half mile north of Fertilla, 2½ miles west and 1½ miles south of Blythe, 1½ miles west of Neighbours, 2 miles south of Ripley, 2½ miles south of Ripley, 1 mile south of Rannells, and 1¾ miles south of Rannells; and at 6½ feet, 2¼ miles south of Rannells.

Many of the old sloughways which have not been obliterated and which have a depth of 3 feet or more contain water. This is partly due to the fact that they are often used as waste ditches, but in many cases it represents the actual water table.

The high water table, with its accompanying alkali accumulations, has resulted in a serious condition, which, unless remedial measures are taken, will become worse. As described elsewhere, the alkali content of the valley soils is sufficiently high, if concentrated at or near the surface, to be harmful to crops. A high water table in a region where evaporation is excessive can result in no other condition than a high concentration of these soluble salts on the surface. In some cases this has already occurred, but, fortunately, to no great extent upon lands under cultivation. It has, however, reached a state in which the extension of farming into alkali areas is precarious.

The necessity for drainage in this valley was appreciated from the beginning of irrigation. This is probably due to the experience many of the farmers obtained while operating in the Imperial Valley, where irrigation, soil, climatic, and other conditions are similar. The first drainage work, in the nature of protection from overflow, was undertaken by the Palo Verde Land & Water Co. during the early years of its development. This company was superseded in 1908 by the Palo Verde Mutual Water Co., which continued to strengthen the existing levees and to construct new ones.

In 1914 the Palo Verde Levee District was organized, comprising all the valley land between the present levee and the mesa. In 1918 this district voted $1,285,000 in bonds, the proceeds of which have

since been used to complete the levee system. The system would have been completed in 1922 had not the flood of this year interfered.

Since the organization of the levee district there has been organized the Palo Verde Drainage District, comprising practically all of the valley land west of the levee and including some small areas near the mesa not included in the levee district. This district has voted $850,000 in bonds, $250,000 of which have been issued. Plans of considerable magnitude have been prepared for the drainage of the valley looking toward the permanent lowering of the water table over the entire area to such an extent that the productiveness of the valley will not be impaired by either high water table or alkali accumulations.

There has already been constructed one large open drain along the levee which collects and carries away seepage. At a point about 2 miles east of Ripley this drain leaves the levee and follows west along the township line to the head of Laguna Palo Verde. This so-called "township" drain is the first of a series of east-to-west drains that it is proposed to construct. The plans specify that these drains shall be 2 miles apart and have an average depth of about 10 feet. At the west side of the valley the water will be taken from the various laterals by a large north and south main having its outlet in the laguna. Because of the slope of the land and the serious danger in cutting the levees, Laguna Palo Verde will be the ultimate outlet for all of the interior drainage of the valley.

In order to avoid the silting up of the main drain by wash from the mesa lands to the west, the district proposes to use all of the material excavated from the drain in the construction of a levee located on the west bank of the drain. The most serious trouble is expected from storm water coming from the mountains and mesa through McCoy Wash. By the construction of a levee as described, the débris carried by McCoy and other washes will be deposited between the levee and the mesa lands and the comparatively clear water will be taken into the drain at some point well to the south.

The construction of lateral drains running from east to west is based on the theory that they will act largely as intercepting drains and relieve the soil of water as it passes southward or southwestward through the relatively pervious subsoils and along the route of the old overflow channels and sloughways. This theory is borne out, at least partly, by observations on a number of test wells which are being maintained by the drainage district and which are being measured periodically.

The soils of this valley predominantly have light subsoils, thus a favorable medium is usually found for the lateral movement of water. The efficiency of deep open drains is demonstrated by the township drain already constructed which is said to have carried upward of 130 cubic feet per second. The stage of the river, however, has considerable influence on the amount of seepage through the levee, as there has been observed a variation of about 60 cubic feet per second between the maximum and minimum discharge of this drain as the result of rise and fall in the river.

A promising feature of the drainage operations in the valley is their inception at a date when the valley is only partly developed and

farmed land is not yet seriously injured. By providing drainage at this time the serious difficulties encountered in other localities by having once productive farms water-logged and abandoned may be avoided.

It would appear that the removal of the excess water from the soils of this valley will be more simple than has been observed on the heavier soils of the Imperial Valley. The light subsoils of the Palo Verde Valley no doubt have in a measure hastened the rise in water table on lands not yet irrigated, but this same feature will also materially aid in their drainage.

Upon the lowering of the water table will depend the success of subsequent leaching to wash the surface accumulations of alkali back into the subsoil. In areas of such low rainfall it is usually necessary to leach the injurious soluble salts from the surface by the application of copious amounts of water.

In the Palo Verde Valley, as elsewhere in new irrigated sections, especially where abundant water is available, there is a tendency to irrigate in a wasteful manner. The obtaining of early returns from the land with the least expense and effort is often looked upon as more essential than water conservation, even though the former course leads to water-logging and final abandonment of the land. A better preparation of the land for irrigation, and irrigation checks or borders laid out with reference to the character of the soil, would materially reduce the volume of water required and consequently reduce the loss. Although checks one-quarter mile long may be justified on the heavy soils which take water slowly they are not best suited for lands which are sandy and upon which the losses are excessive in attempting to irrigate long checks.

Improvements in the methods of irrigation usually follow the more intensive development of an area, but not always until after considerable damage has been done. It is obviously inconsistent to provide costly drainage for lands upon which improper methods of irrigation are continued.

SUMMARY

The Palo Verde area is situated in the extreme southeast part of California and has an area of 423 square miles, or 270,720 acres. It is bounded on the east by the Colorado River, which separates it from Arizona, and on the north, south, and west by desert plains and barren mountains. The area is in two divisions, the low, recent-alluvial Palo Verde Valley, and the higher desert mesa with included mountain areas bordering it on the north and west. The elevation of most of the valley is lower than the river and in order to obtain protection from overflows, prevalent in the past, a levee is being built the entire length of the valley. At present the water table is high, but provision has been made for installing a complete drainage system. Prior to settlement the valley was thickly covered with mesquite and other shrubs, but most of this has been removed from the northern part and the land brought under irrigation.

The mesa is separated from the valley by a steep escarpment 80 to 130 feet in height. Its surface is fairly level, but the elevation is such that irrigation development would be costly and apparently would be unjustified under present agricultural conditions.

The population of the valley is estimated at 7,000. Blythe, the principal town, has a population of 1,622. Transportation facilities are good throughout the northern and central parts of the valley, there being no point in these sections more than 5 miles distant from a shipping point. The road system is adequate for the needs of present settlement, but many of the country roads are in bad repair. Blythe is an important local market. Los Angeles provides a ready market for livestock and livestock products, and cotton and truck crops are shipped to eastern markets.

The climate of the Palo Verde area is arid, the mean annual precipitation at Blythe being 4.26 inches. The winters are mild and the summers are long and hot, temperatures of 100° F. or more being recorded for every month from March to October, inclusive, with a maximum temperature of 121° F. Killing frosts are of rare occurrence, vegetables being grown throughout the winter months, the more tender ones being protected for a time with oiled-paper coverings. The mean annual temperature is 68.7° F. and the normal growing season 251 days in length.

Settlement is confined to the valley part of the area. Agriculture is entirely by irrigation and consists of the growing of cotton for sale, the raising of alfalfa and grain hay for feeding work stock, cattle, and hogs, and to a less extent the production of truck crops for market and for home use. Dairying and poultry raising are locally important and there is a large acreage recently planted to grapes.

In 1920 nearly three fourths of the cultivated acreage was devoted to cotton, while cotton and alfalfa combined occupied nearly 90 per cent of the total cultivated area. At the present time (1922) the tendency is to reduce the acreage of cotton and to increase the acreage of alfalfa and truck crops.

The agriculture of the Palo Verde Valley is of the year-round type, and some of the most highly specialized crops, such as cantaloupes, lettuce, and tomatoes, are grown during the winter months.

As the valley has but recently been settled, many of the farm buildings are cheaply constructed and of a temporary character. The work stock consists of small to medium sized horses, but much farm work is done with tractors, and other improved machinery and labor-saving devices are in general use.

Most of the farms range in size from 40 to 160 acres, although there are some containing 2,000 acres or more. The largest farms are devoted principally to stock raising. Well-developed lands in the Palo Verde Valley sell for $150 to $200 an acre. Undeveloped land can be bought for $25 to $50 an acre.

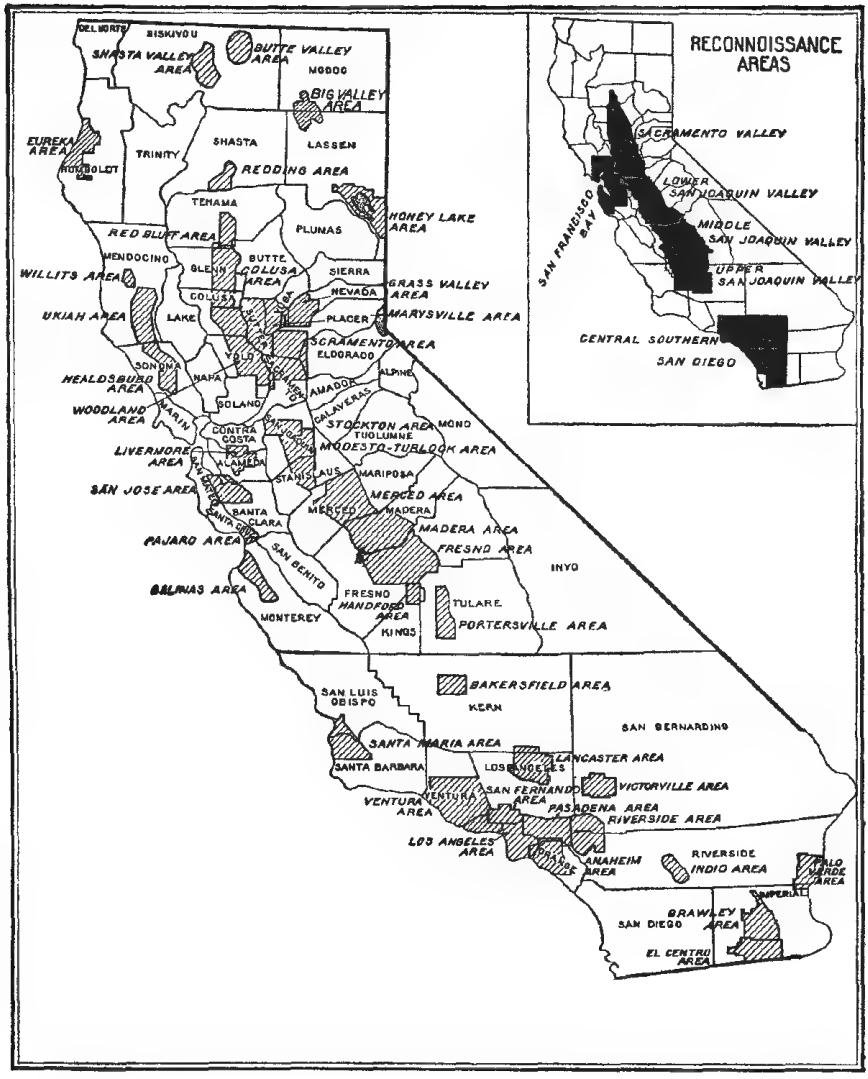
The Palo Verde area lies in the southwest desert region. About one-third of it lies in the irrigated Palo Verde Valley bordering the Colorado River, and the remainder on the desert 100 feet or more above all present sources of irrigation water. The valley soils consist mainly of recent-alluvial deposits left by recurring overflows of the Colorado River, including materials which have been modified by winds and probably some material drifted into the valley from the desert mesa. They are mainly of fine texture, free from stone or gravel, calcareous, low in humus content, and characteristically chocolate brown or purplish brown in color. They have been

grouped into six series—the Carrizo, Imperial, Holtville, Gila, Meloland, and Rositas. The Carrizo soils consist of light-colored, coarse-textured materials and are confined to narrow washes issuing from the desert. The Imperial series consists typically of relatively impervious material to a depth of 6 or more feet; the Holtville, of similar surface soils with lighter textured, permeable subsoils; the Gila, of light-colored recently deposited alluvial sediments having variable stratified subsoils; the Meloland, of loose, permeable wind-modified surface soils and impervious subsoils; and the Rositas, of loose, porous, wind-blown soils and subsoils.

The desert soils consist of old valley filling deposits apparently derived mainly by wash from the near-by mountains, although there are a few deep deposits of highly polished gravels indicating a possible marine or lake shore source of origin. Most of these soils are maturely weathered and all are highly calcareous. All contain varying quantities of gravel, and for some distance out from the mountains the content of stones is sufficient to render them unfit for cultivation. They have been grouped in two series—the Tijeras and the Superstition. The Tijeras series consists of pinkish-gray or pale-red compact soils with reddish or pinkish-colored, compact, or loosely cemented subsoils. The Superstition series is less red in color, less compact, and has a lower content of lime. Being above the source of irrigation water, these soils are entirely undeveloped.

Irrigation water for the valley is derived by gravity from the Colorado River and the supply is relatively abundant. Certain sections are affected by alkali, and most of the valley is in need of artificial drainage, plans for which are already financed. Less than one-half of the valley has been developed, and there are apparently excellent opportunities for settlement.

○



Areas surveyed in California, shown by shading

Accessibility Statement

The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at (800) 457-3642 or by e-mail at ServiceDesk-FTC@ftc.usda.gov. For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at http://offices.sc.egov.usda.gov/locator/app.

The USDA Target Center can convert USDA information and documents into alternative formats, including Braille, large print, video description, diskette, and audiotape. For more information, visit the TARGET Center's Web site (http://www.targetcenter.dm.usda.gov/) or call (202) 720-2600 (Voice/TTY).

Nondiscrimination Policy

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees, and applicants for employment on the basis of race, color, national origin, age, disability, sex, gender identity, religion, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, whether all or part of an individual's income is derived from any public assistance program, or protected genetic information. The Department prohibits discrimination in employment or in any program or activity conducted or funded by the Department. (Not all prohibited bases apply to all programs and/or employment activities.)

To File an Employment Complaint

If you wish to file an employment complaint, you must contact your agency's EEO Counselor (http://directives.sc.egov.usda.gov/33081.wba) within 45 days of the date of the alleged discriminatory act, event, or personnel action. Additional information can be found online at http://www.ascr.usda.gov/complaint_filing_file.html.

To File a Program Complaint

If you wish to file a Civil Rights program complaint of discrimination, complete the USDA Program Discrimination Complaint Form, found online at http://www.ascr.usda.gov/complaint_filing_cust.html or at any USDA office, or call (866) 632-9992 to request the form. You may also write a letter containing all of the information requested in the form. Send your completed complaint form or letter by mail to

U.S. Department of Agriculture; Director, Office of Adjudication; 1400 Independence Avenue, S.W.; Washington, D.C. 20250-9419; by fax to (202) 690-7442; or by email to program.intake@usda.gov.

Persons with Disabilities

If you are deaf, are hard of hearing, or have speech disabilities and you wish to file either an EEO or program complaint, please contact USDA through the Federal Relay Service at (800) 877-8339 or (800) 845-6136 (in Spanish).

If you have other disabilities and wish to file a program complaint, please see the contact information above. If you require alternative means of communication for program information (e.g., Braille, large print, audiotape, etc.), please contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

U. S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
IN COOPERATION WITH THE
UNIVERSITY OF CALIFORNIA
AGRICULTURAL EXPERIMENT STATION

ALKALI MAP

CALIFORNIA
PALO VERDE SHEET

R. 20 E. | R. 21 E. | R. 22 E. | R. 23 E.

T. 5 S. | T. 6 S. | T. 7 S. | T. 8 S. | T. 9 S.

Floyds
Fertilla
BLYTHE
Ripley
Rannells
Palo Verde
PALO VERDE MESA
ATCHISON TOPEKA AND SANTA FE
COLORADO RIVER
RIVERSIDE CO.
IMPERIAL CO.

A — Alkali affected areas

Note:
Location of borings and result of field tests shown thus, •14/43
The upper figure shows the percentage concentration in the surface foot.
The lower figure shows the average concentration to a depth of six feet.

Alkali surveyed by A. E. Kocher, in charge, and F. O. Youngs

Scale 1 inch = 2 miles
2 1½ 1 ½ 0 2 4 6 Miles

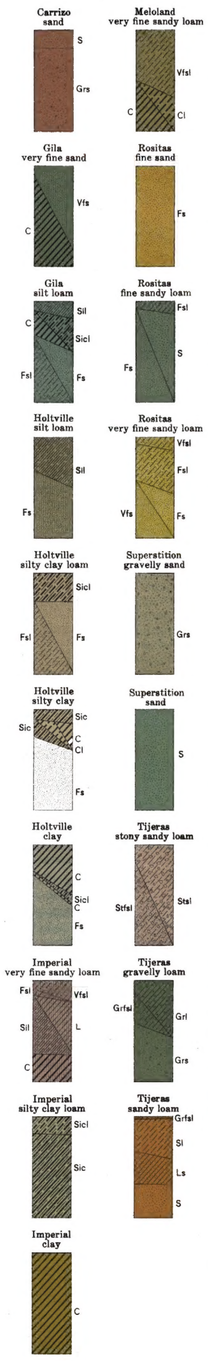
Field Operations
Bureau of Soils
1922

U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF SOILS
IN COOPERATION WITH THE
UNIVERSITY OF CALIFORNIA
AGRICULTURAL EXPERIMENT STATION

SOIL MAP

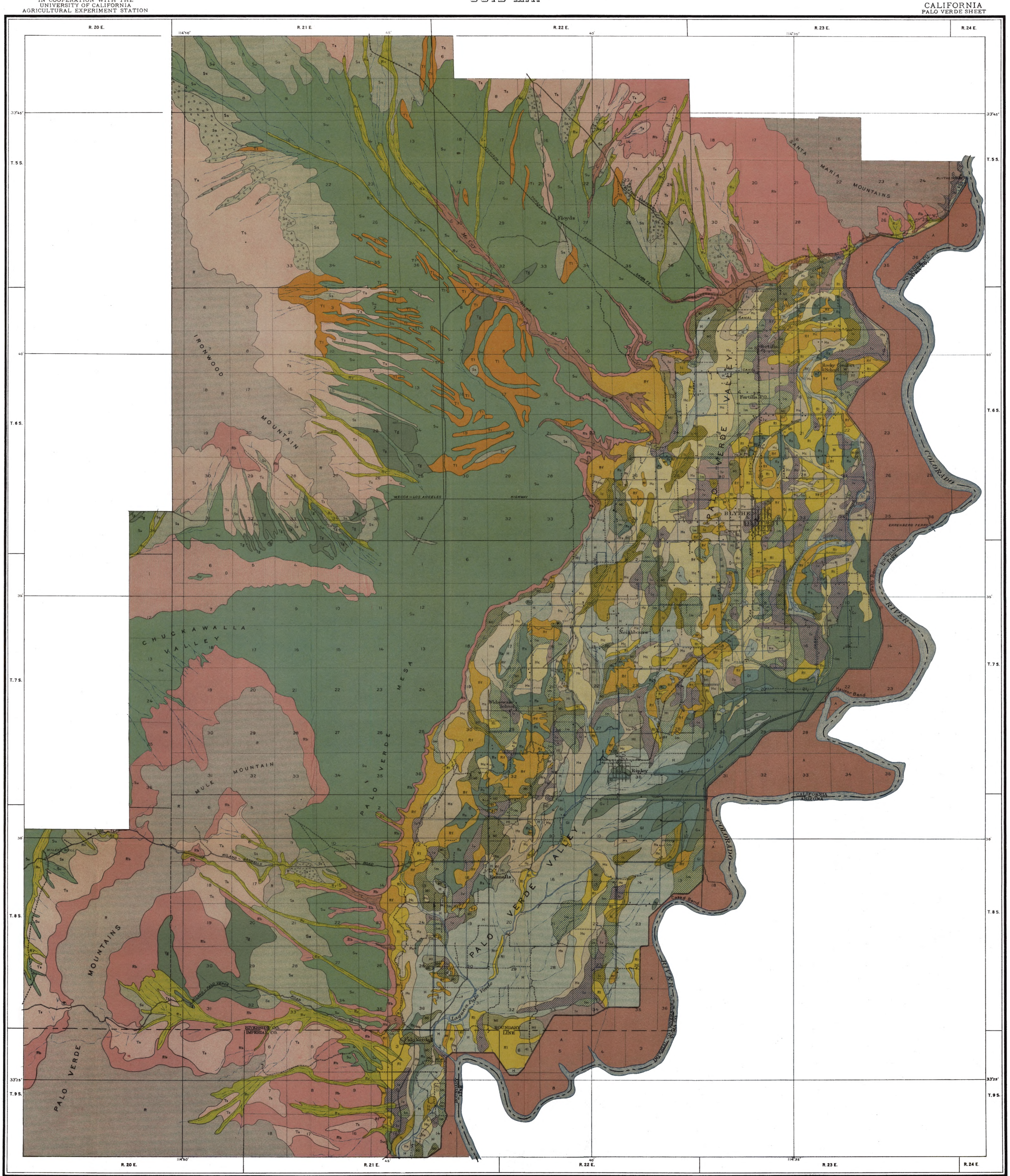
CALIFORNIA
PALO VERDE SHEET

TEXTURAL SECTIONS
(6 feet deep)



LEGEND

Grs	Gravelly sand
S	Sand
Fs	Find sand
Vfs	Very fine sand
Ls	Loamy sand
Stsl	Stony sandy loam
Grsl	Gravelly sandy loam
Sl	Sandy loam
Stfsl	Stony fine sandy loam
Grfsl	Gravelly fine sandy loam
Fsl	Fine sandy loam
Vfsl	Very fine sandy loam
Grl	Gravelly loam
L	Loam
Sil	Silt loam
Sicl	Silty clay loam
Cl	Clay loam
Sic	Silty clay
C	Clay



LEGEND

Carrizo sand — C	Meloland very fine sandy loam — Ml
Gila very fine sand — Gv	Ml — Stratified phase
Gila silt loam — Gl	Rositas fine sand — Rf
Holtville silt loam — Hl	Rositas fine sandy loam — Rs
Holtville silty clay loam — Hs	Rositas very fine sandy loam — Rl
Holtville silty clay — Hc	Superstition gravelly sand — Ss
Holtville clay — H	Ss — Stony phase
Imperial very fine sandy loam — Iv	Superstition sand — Su
Iv — Stratified phase	Tijeras stony sandy loam — Ts
Imperial silty clay loam — Im	Tijeras gravelly loam — Tg
Im — Stratified phase	Tijeras sandy loam — Tl
Imperial clay — Ic	Riverwash — Rv
Ic — Stratified phase	Rough stony land — R
Dunesand — D	Rough broken land — Rb

Alluvial soils
(Undifferentiated-flooded annually) — A

CONVENTIONAL SIGNS

CULTURE
(Printed in black)

City or Village, Roads, Buildings, Wharves, Jetties, Breakwater, Levee, Lighthouse, Fort

Secondary roads and Trails

Railroads Steam and Electric

Bridges, Ferry

R.R.crossings, Tunnel

Ford, Dam

School or Church Cemeteries

Mine or Quarry Mine dumps Made land

Bluff, Escarpment, Rock outcrop and Triangulation station

Stony and Gravelly areas

Soil boundaries

Boundary lines

Boundary lines

Boundary lines

U.S.township and section lines

RELIEF
(Printed in brown or black)

Contours Depression contours

Prominent Hills Mountain Peaks

Sand, Wash, and Sand dunes

Shore and Low water line, Sandbar

DRAINAGE
(Printed in blue)

Streams

Lakes, Ponds, Intermittent lakes

Intermittent streams

Springs, Canals and Ditches, Flumes

Swamp Salt marshes

Submerged marsh Tidal flats

The above signs are in current use on the soil maps Variations from this usage appear in some maps of earlier dates

Soils surveyed by A. E. Kocher, in charge, and F. O. Youngs

Scale 1 inch = 1 mile
1 ½ 0 1 2 3 4 Miles

WILLIAMS-WEBB CO., WASH., D.C.

Field Operations
Bureau of Soils
1922